Wastewater Treatment, Water Reuse and Water supply incl. Rain/Flood harvesting

Workshop

PD Dr. Thomas Kluge

ISOE – Institute for Social-Ecological Research, Frankfurt/Main

First Kenyan-German Water and Wastewater Week

Nairobi, October 11th, 2016

Workshop Overview

- Wastewater treatment (45 minutes)

  Description and analyses by the participants

  - Technical Layout
  - Organisation
  - Problems in different parts of the town

Institute for Social-Ecological Research

Wastewater Treatment, Water Reuse and Water supply incl. Rain/Flood harvesting

Workshop

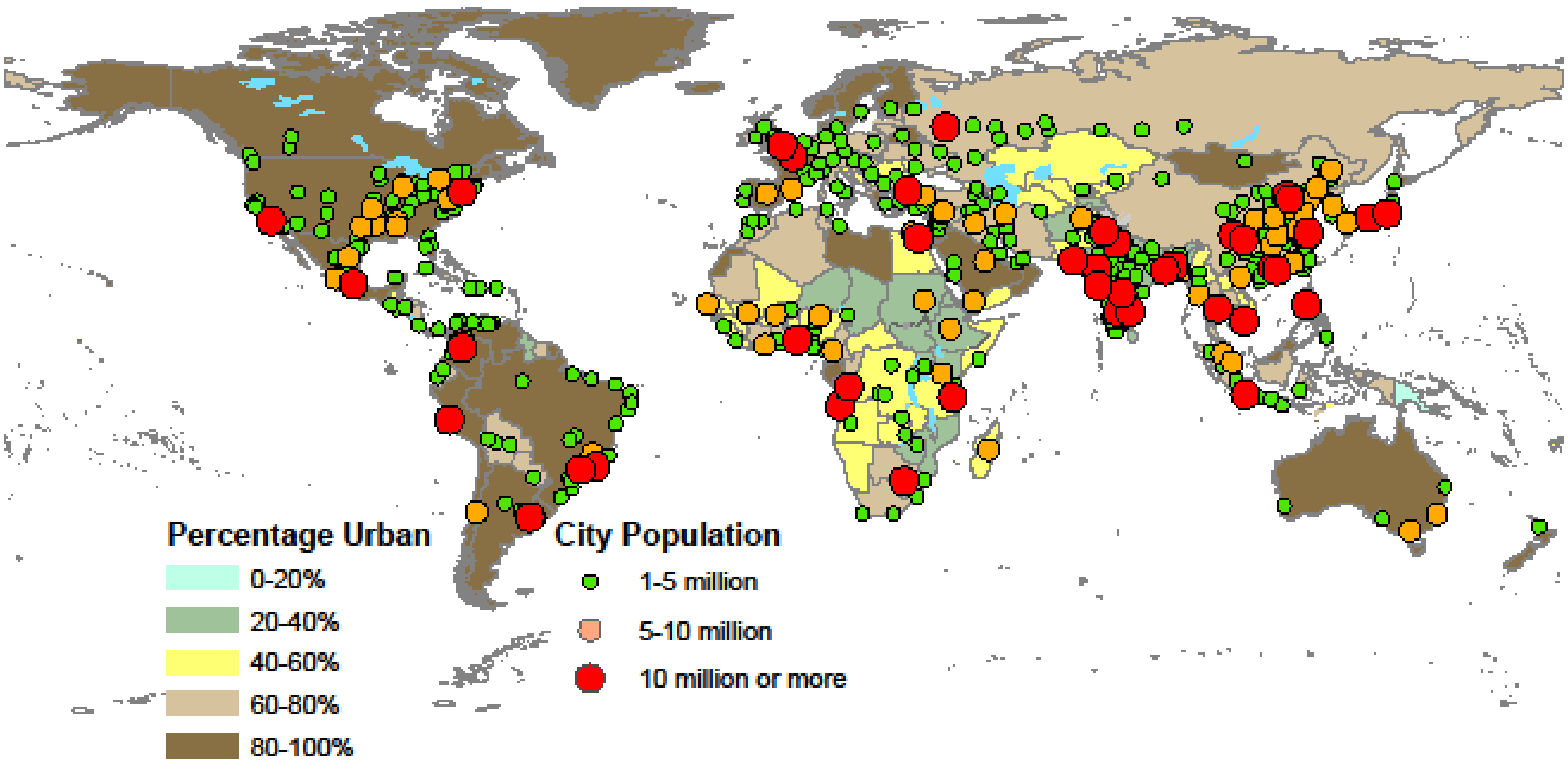
PD Dr. Thomas Kluge

ISOE – Institute for Social-Ecological Research, Frankfurt/Main

First Kenyan-German Water and Wastewater Week

Nairobi, October 11th, 2016

The Challenge: Urbanization of the Planet



Note: Designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The Challenge: Urbanization of the Planet

Institute for Social-Ecological Research

1. Population Growth: At present, the population of the world is approx.
7.2 billion with 60% living in Asia,
5.7% in Africa, 13.4% in the Americas
and 10.4% in Europe.
The UN expects the world's population to increase to 8.17 billion by 2025 and 10.9 billion by 2100.

2. Urbanization: The population explosion is particularly noticeable in urban regions. According to estimates, 2/3 of the world's population will live in urban settlements by 2050.

3. Limited Resources: Increased resource consumption in parallel with urban growth would lead to a collapse, an exhaust of resources.

The Challenge: Urbanization of the Planet

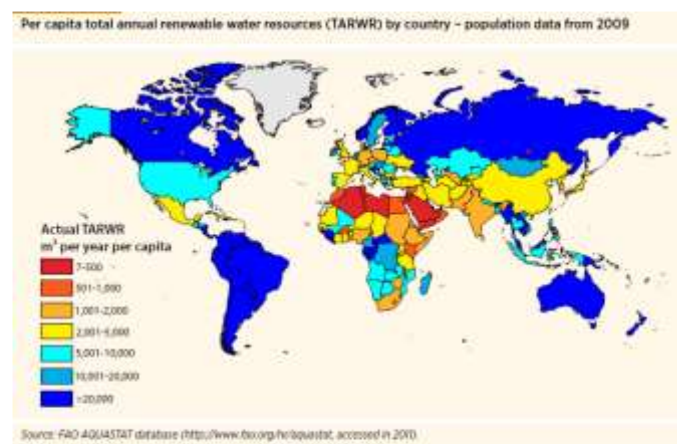
Institute for Social-Ecological Research

<u>4. Health and Environment:</u> Each year about 3 million people worldwide die as a consequence of polluted water. This certainly also refers to the fact that at present only 20% of the world's population is even connected to a wastewater system and, therefore, to hygienic sanitary facilities.

The Challenge: Urbanization of the Planet

Institute for Social-Ecological Research

<u>6. Water Scarcity:</u> Asia only has 36% of global water resources. Growth of population and economy will raise water demand. Climate change will prolong droughts. Water scarcity continues to grow exorbitantly.



The Consequence:
Global importance of preserving water

Institute for Social-Ecological Research

➢**We** **CANNOT** **cover future water demand on the base of current resource consumption !**

➢**We** **CANNOT** **proceed as before, i.e. business as usual leads us into disaster !**

➢**We** **CAN** **basically improve resource efficiency by a fundamental change in urban water management !**

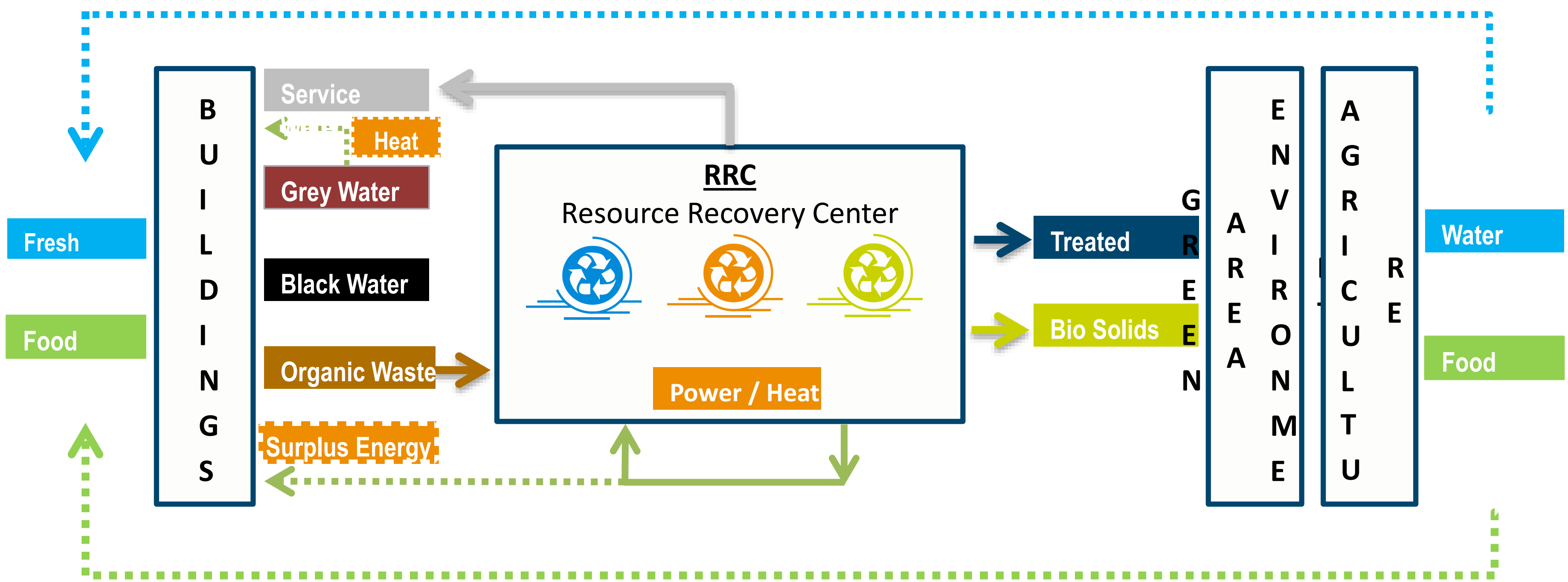
The Vision 2050: Water for a Sustainable World UN World Water Development Report (WWDR 2015):

- *Water is duly valued in all its forms, with* ***wastewater treated as a resource*** *that avails energy, nutrients and freshwater for reuse.*
- ***Integrated approaches*** *to water resources development, management and use − and to human rights − are the norm.*

Innovative Water Management

Institute for Social-Ecological Research

Solution Resource Recovery Centers (RRCs) are designed to integrate material and energy flows for improved efficiency



EPoNa –
Water Reuse in Northern Namibia

PD Dr. Thomas Kluge

ISOE – Institute for Social-Ecological Research, Frankfurt/Main

First Kenyan-German Water and Wastewater Week

Nairobi, October 11th, 2016

Aim of the Project

Institute for Social-Ecological Research

- Improve the efficiency of wastewater ponds
- With focus on:
  - Technical measures targeted towards water reuse for irrigation purposes
  - Sustainable operation of water treatment and irrigation facilitated by training sessions and management structures
  - Transfer potentials

Research Approach

Institute for Social-Ecological Research

- Research approach:
  - Integrated systems approach which comprises wastewater collection, treatment and reuse
- Case study:
  - Wastewater pond in Outapi, central-northern Namibia
- Research object:
  - Different methods of water treatment, irrigation and plant cultivation
- Project team:
  - Members from research institutions, practice partners as well as from the municipality

Project Partners

Institute for Social-Ecological Research

Research and project partners

- Technical University of Darmstadt, Institute IWAR, Department of Wastewater Technology
- Institute of Environmental Engineering and Management at the University of Witten/Herdecke
- University of Geisenheim, Institute for soil science, plant nutrition and vegetable gardening
- Aqseptence Group, Hanau
- H. P. Gauff Ingenieure GmbH & Co. KG – JBG

Practice partners

- Outapi Town Council (OTC)
- Ministry of Urban and Rural Development (MURD)
- Ministry of Agriculture, Water and Forestry (MAWF)
- University of Namibia (UNAM)
- Namibia University of Science and Technology (NUST)
- Olushandja Sub Basin Management Committee (OLBMC)

Background

Institute for Social-Ecological Research

- Sustainable reuse of water resources is one of the UN Sustainable Development Goals (SDG)
- EPoNa contributes to the SDGs by improving already existing solutions for water treatment by adding approaches with regard to water reuse for arid regions
- Livestock farming is of high economic and socio-cultural significance in northern Namibia
- Project aims to provide sufficient amounts of irrigation water for the production of animal feed throughout the year
- Water treatment and reuse can minimize contaminations in case of flooding and thus reduce health risks for the population
- Methane emissions caused by insufficient water treatment are decreased with the help of the proposed approaches

→ **EPoNa's water reuse concept directly connected with agricultural production, health, and climate protection**

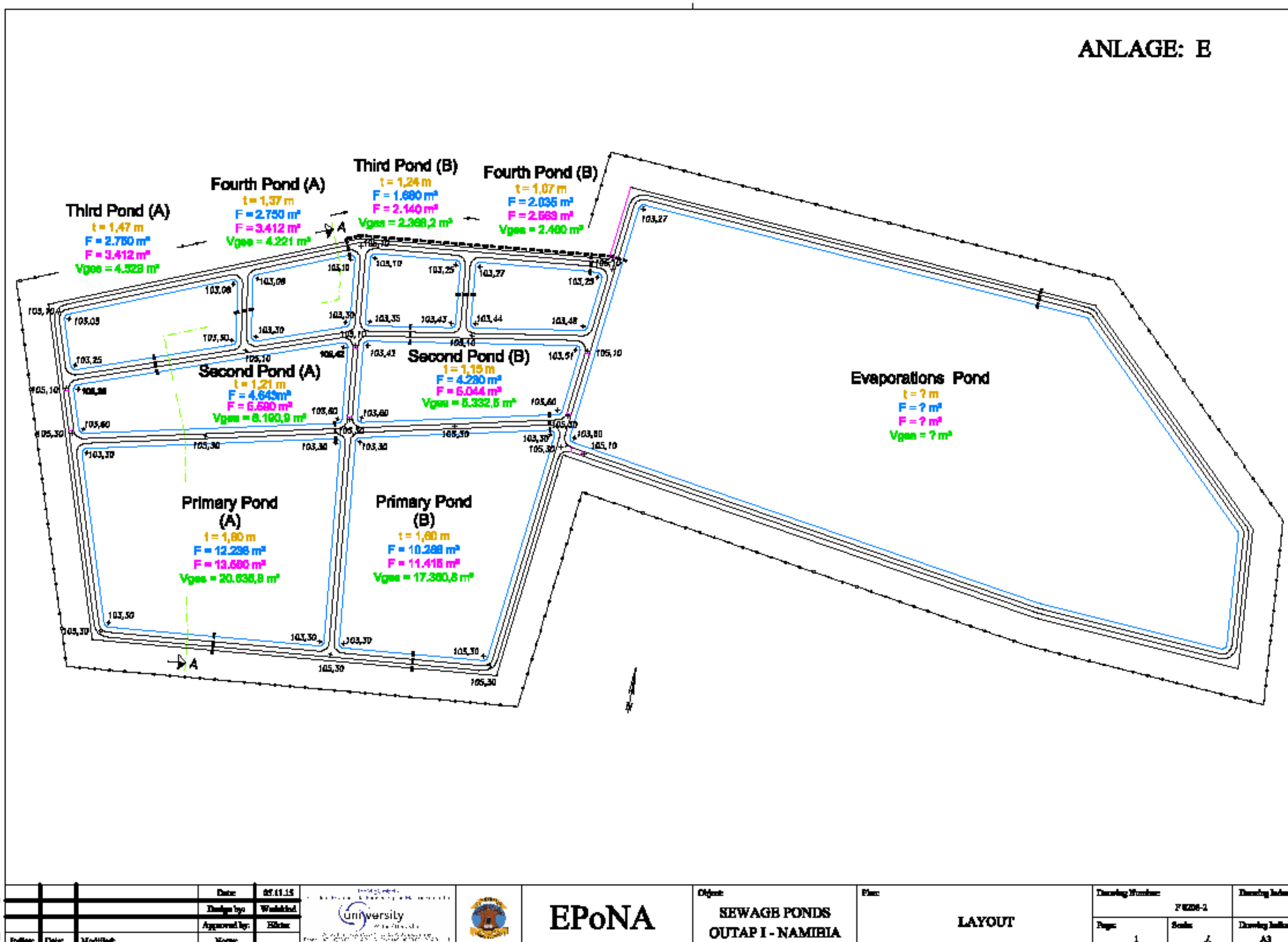
Further Project Information

Institute for Social-Ecological Research

- Funding:
  - EPoNa is funded by the BMBF funding measure “Future-Proof Technologies and Concepts to Increase Water Availability and Desalination” (WavE).
- Duration:
  - 09/2016–08/2019

Existing Evaporation Ponds in Outapi

Institute for Social-Ecological Research



Impressions of the Evaporation Ponds in Outapi

- Wastewater inlet

- Surface of pond 1 (methane bubbles)

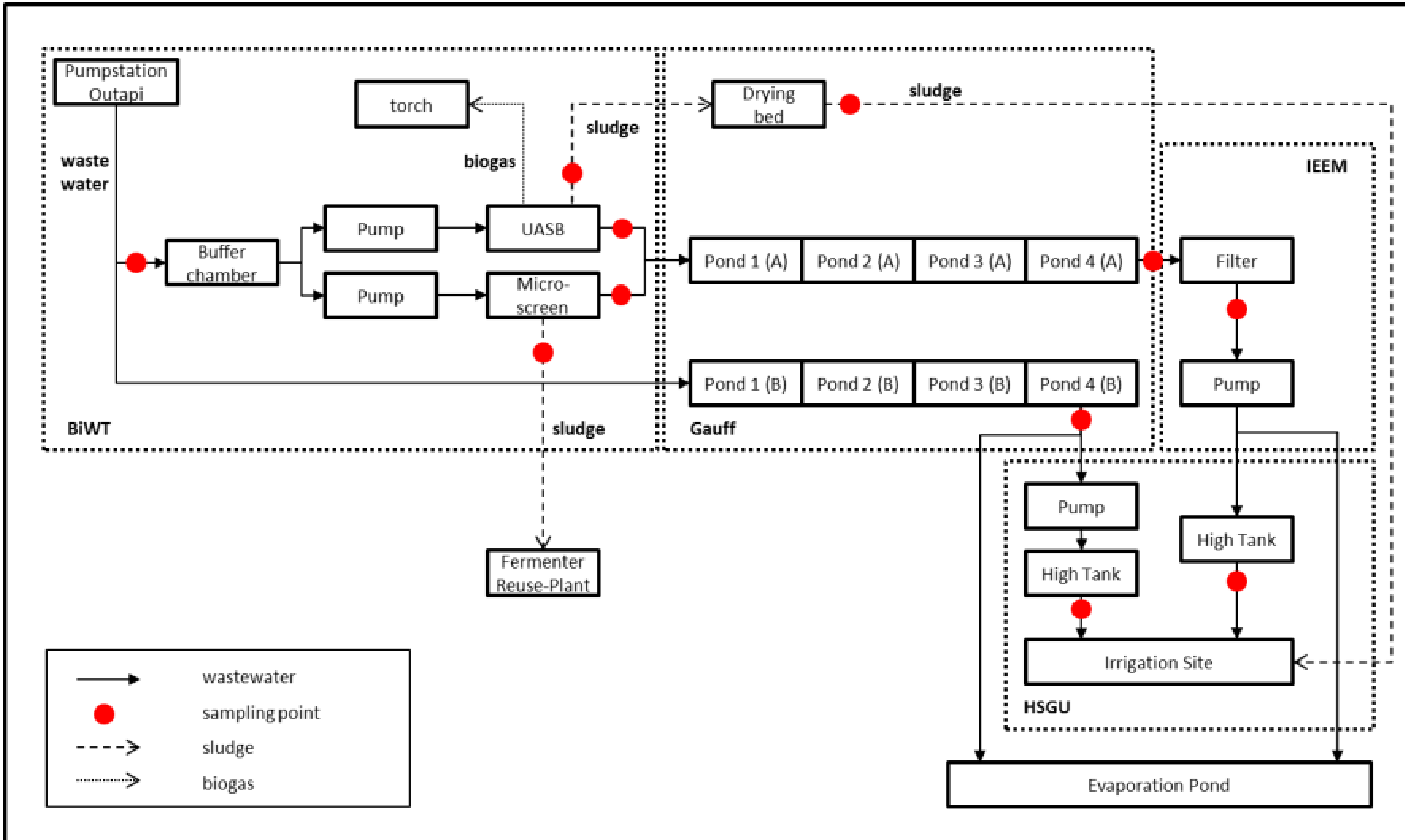
- Wastewater outlet

Measured Values, Outapit, Autumn 2014

Parameter	Sample preparation	Inlet	Outlet	Unit
COD	homogenised	460	360	mg/l
COD	filtered, 0.45µm	130	110	mg/l
P_{tot}	filtered, 0.45µm	11,5	11	mg/l
N_{tot}	filtered, 0.45µm	74	66	mg/l
NH_4-N	filtered, 0.45µm	39	28	mg/l
Total Coliforms	No	1,40E+06	4,8E+04	MPN/100 ml
E. coli	No	3,80E+05	4,1E+03	MPN/100 ml

Scheme of the Proposed Measures

Institute for Social-Ecological Research



Goal 1 – Wastewater Treatment

Institute for Social-Ecological Research

- Improvement and rehabilitation of wastewater ponds in order to produce irrigation water by combining low-tech approaches with technological components
- Reduction of Methane emissions through removal of solids, i.e. reduction of input of organic substances into the ponds
- Increasing the plant capacity through removal of organic substances and, hence, reduced pollution of the ponds
- Comparison of two different techniques to remove primary sludge and its energy recovery
- Improved flow paths
    - To avoid short circuits
    - For better disinfection effects (reconstruction of ponds to tubular reactors)
- Identification, adaptation and demonstration of a treatment technology suitable for the region to separate particles (e.g. algea) and to improve hygiene parameters in order to utilize the water for irrigation purposes

Goal 2 – Governance

Institute for Social-Ecological Research

- Development and implementation of adapted governance structures and wastewater treatment plant partnerships or operator networks
  - E.g. finance controlling
- Development of process organisation structures on different levels (government, ministry, Olushandja Basin Management Committee, Town Council, Operator, UNAM etc.)
- (Further) Development of irrigation agriculture concepts and their social-ecological impact assessment

Goal 3 – Irrigation Agriculture

- Development of a robust low-pressure irrigation system for the usage of pond water for agricultural crops and minimization of water losses
- Development and scientific evaluation of crop systems which are optimally adapted to the irrigation with pond water and the semi-arid conditions
- Iterative optimizing goals:
  - Maximum yields (total system)
  - Maximum product quality (of all single components)
  - Minimum contamination of products with pollutants/pathogens (hygienic harmlessness of products)
  - Improvement of yield potentials (soil fertility)
  - Minimum soil degradation (salinization, accumulation of pollutants, erosion)
  - Optimal usage of water and nutrients from the ponds
- Large-scale implementation of results („proof-of-principle“)

Goal 4 – Economy

Institute for Social-Ecological Research

- Development and estimation of regional economic conditions and effects
- Conceptualization and discussion of an adapted financing model for the rehabilitation, optimization and extension of the wastewater ponds in the case of Outapi

Goal 5 – Social-Ecological Impact Assessment and Transfer

Institute for Social-Ecological Research

- Analysis and assessment of social and ecological interdependencies (social-ecological impact assessment, SEIA)
- Analysis of the transfer potential of the proposed solution Lösungsansatzes auf andere Regionen im südli-chen Afrika (Transferpotentialanalyse)
- Diffusion of results through academic education, training and compilation of a handbook
  - Handbook can be used for training operators and decision makers at existing and future locations to secure the plants' long-term operation

Closing the Water Loop: Sanitation, Water Reuse, and Irrigation in Outapi

PD Dr. Thomas Kluge

ISOE – Institute for Social-Ecological Research

First Kenyan-German Water and Wastewater Week

Nairobi, October 11th, 2016

SPONSORED BY THE

Federal Ministry of Education and Research

Institute for Social-Ecological Research

TECHNISCHE UNIVERSITÄT DARMSTADT

IWAR

FONA Sustainable Water Management BMBF

IN COOPERATION WITH

UNAM

giz

BGR

INDUSTRY PARTNERS

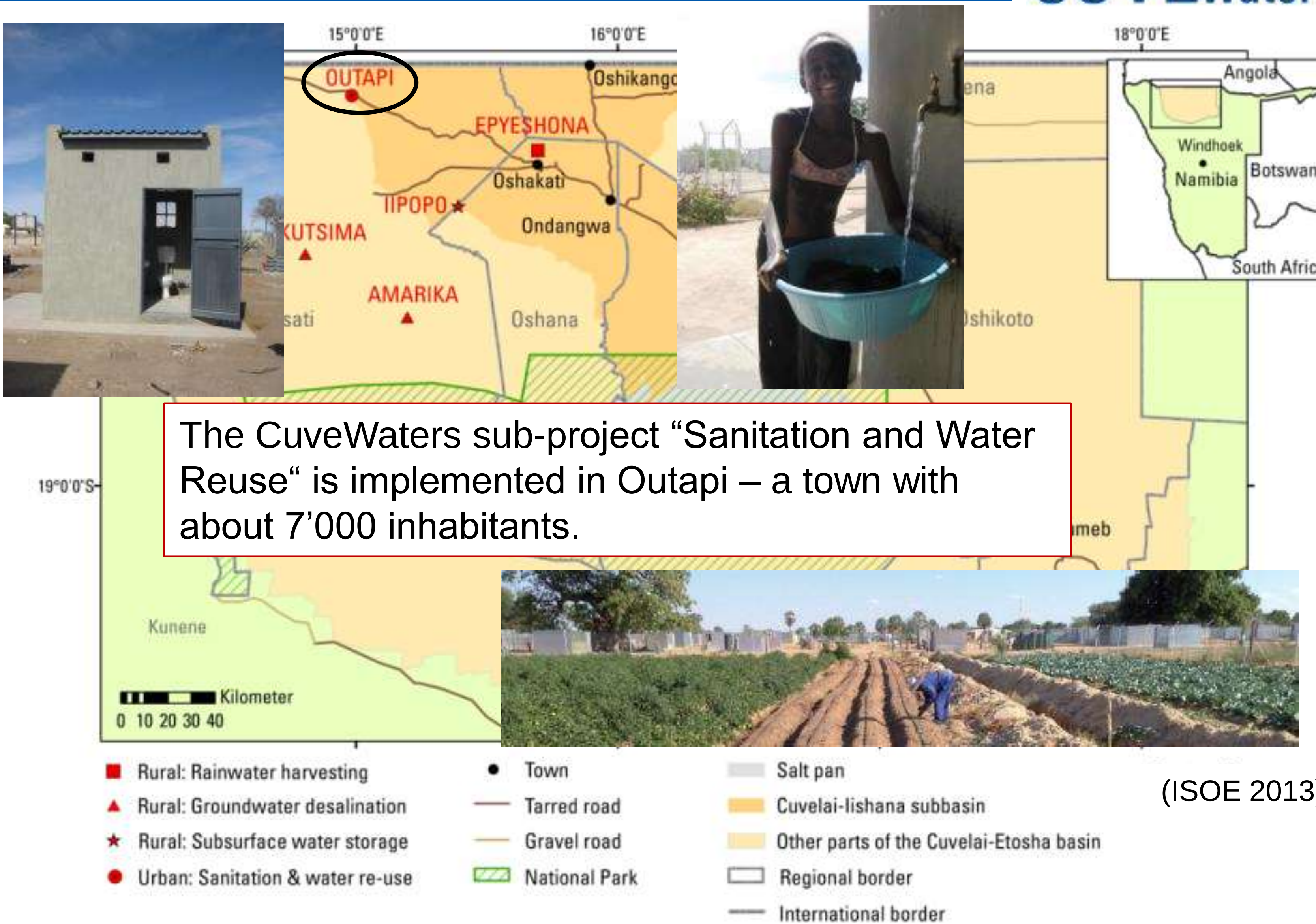
proaqua

terra water

Outline

- Introduction:
  - The IWRM project CuveWaters
  - Framework conditions in the area
- Sanitation and Water Reuse System in Outapi
  - Goal
  - Implementation
  - Results
- Successes and challenges

Introduction – the IWRM project CuveWaters

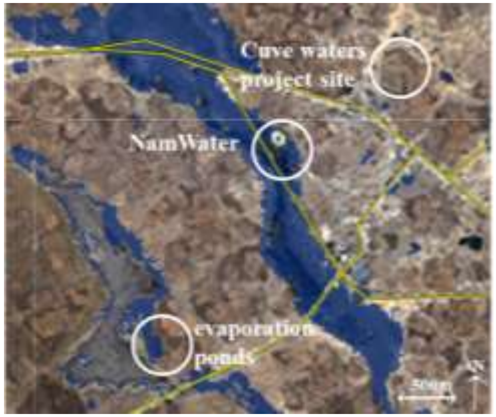


The CuveWaters sub-project “Sanitation and Water Reuse“ is implemented in Outapi – a town with about 7’000 inhabitants.

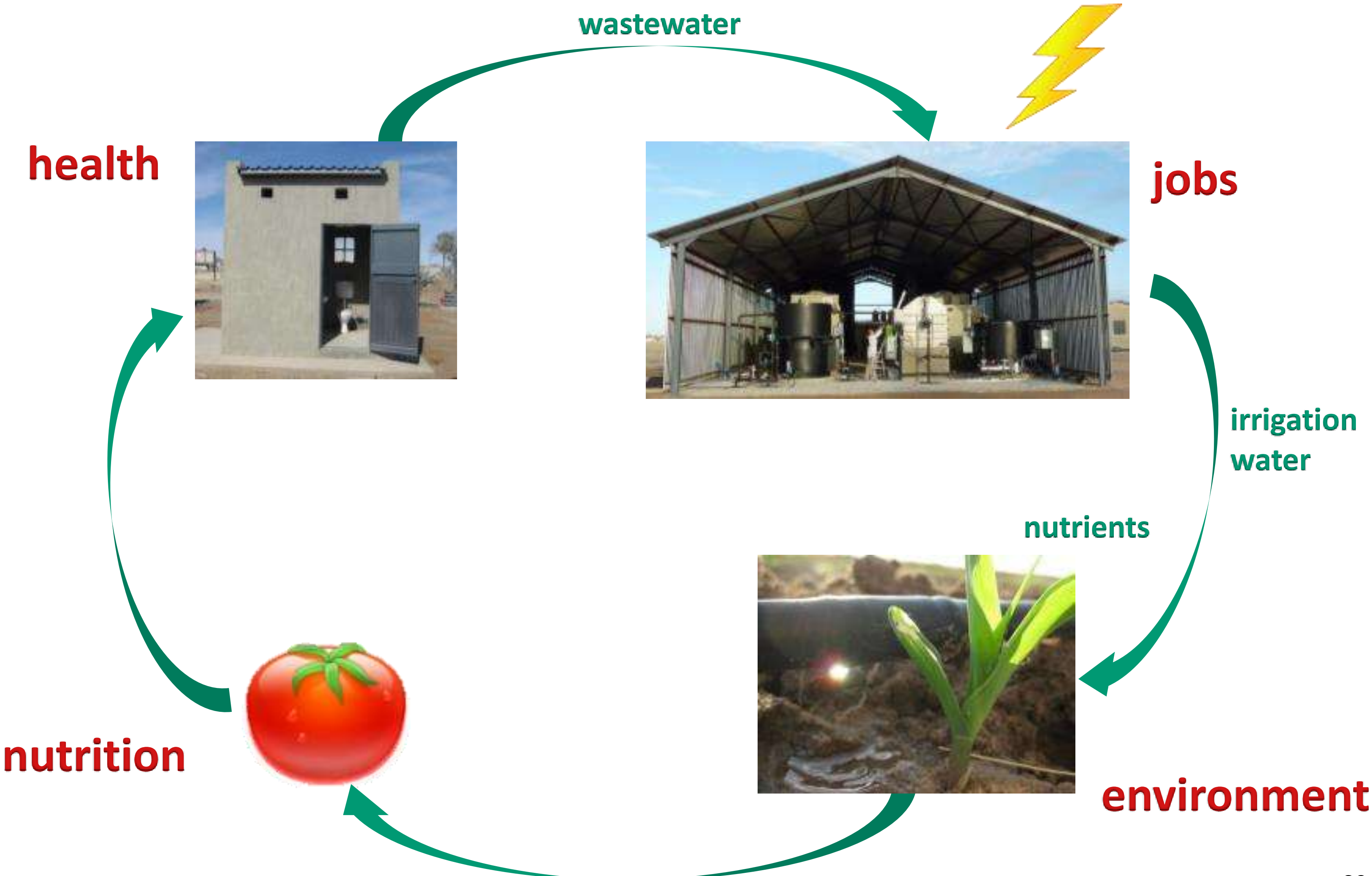
(ISOE 2013)

Introduction – framework conditions in Outapi

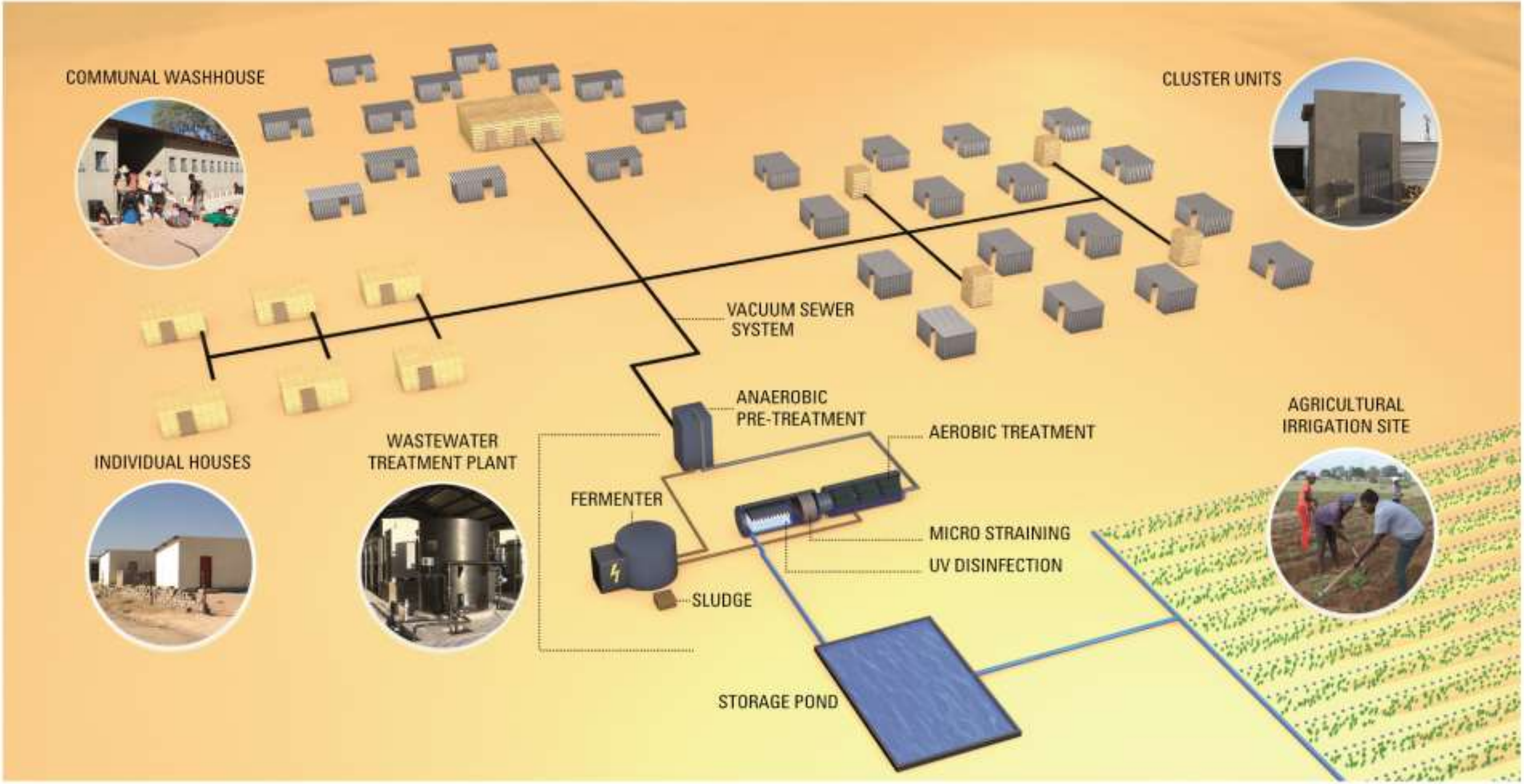
- Informal settlements: unimproved sanitation facilities like pit latrines, “flying toilets” and “bush toilets”
- Developed settlements: gravity sewers and stabilization ponds
- Floods during rainy season
- Dynamic development of urban settlements
- Sandy, nutrient-poor soils and need for irrigation



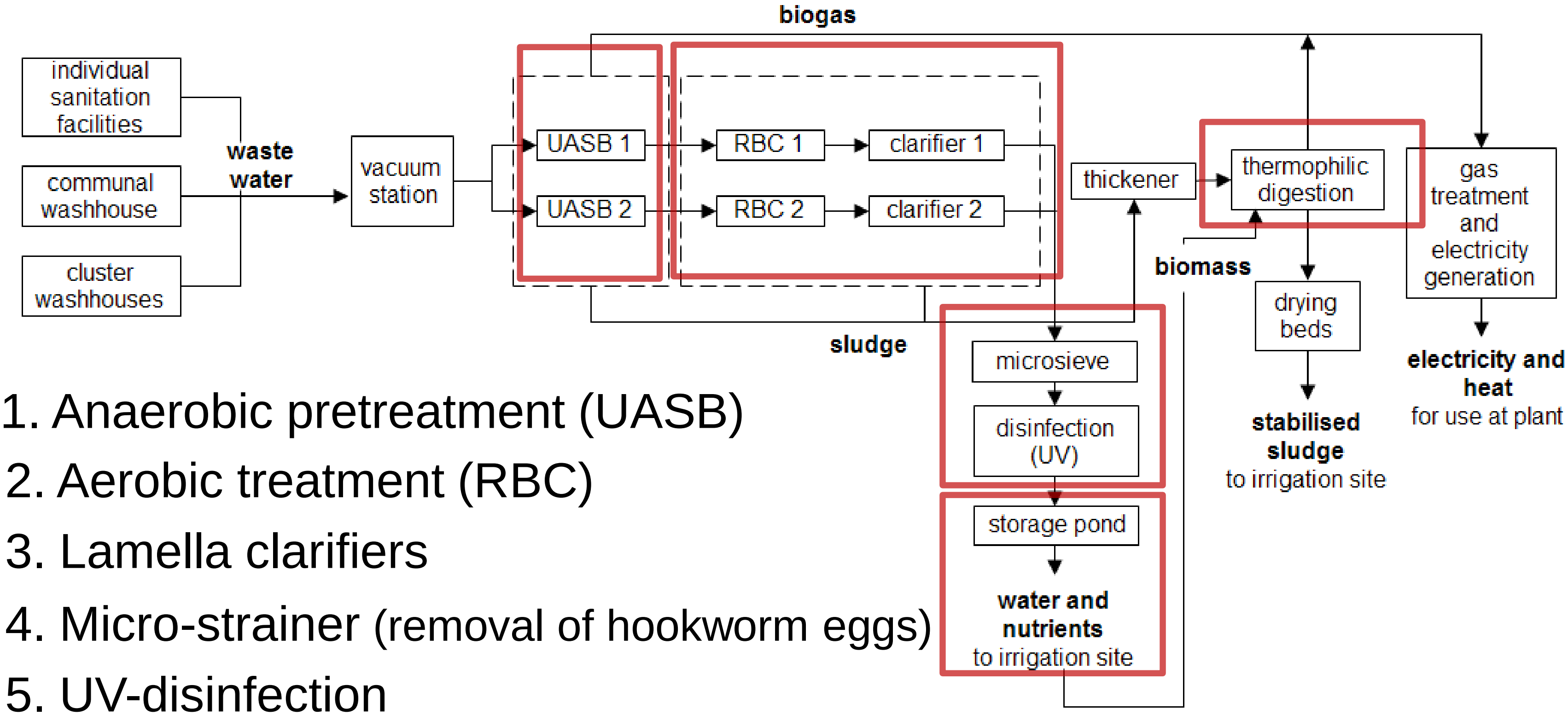
Implementation: Goal



Implementation



Treatment steps



1. Anaerobic pretreatment (UASB)
2. Aerobic treatment (RBC)
3. Lamella clarifiers
4. Micro-strainer (removal of hookworm eggs)
5. UV-disinfection
6. Storage pond
7. Irrigation site
8. Fermenter

Multi-barrier Approach

Approximate concentrations per 1 Liter of water		**E.coli**	**Rotavirus**	**Hookworm eggs**
	Sanitation facilities	100,000,000	500,000	Up to 3‘000
	Treatment Plant	200	10^{-3}	1 – 770[1]
	Storage Pond	70	-	None detected
	Drip Irrigation	2	10^{-5}	None detected
	Fruits	0.02	10^{-7}	None detected

[1] *Depending on performance of micro-strainer*

Results – Effluent Water Quality

CUVE waters integrated water resources management

- Average values for the monitoring period June’14 – June’15

Capacity: 90 m^3/d!!!	Influent (actual)	Effluent	Removal Efficiency
Q [m^3/d]	30 – 50(1)		
COD_{tot} [mg/L]	742	56	92%
BOD_5 [mg/L]	236	6	97%
TS [mg/L]	781	383	51%
EC [µS/cm]	617	527	-
TN [mg/L]	58	34	-
TP [mg/L]	10	8	-
E.Coli [MPN/100 mL]	$17 \cdot 10^6$	34	[illegible]

(1) [illegible] tariff

Fit for purpose!!!

Results – Operation & Maintenance

- 2 full-time operators, training prior to operation and training “on the job”
- Constant support by manufactures
- “Hotspots” maintenance:
  - Micro-strainer (cleaning)
  - Inlet pumps (rotary lobes)
  - Misuse in sanitation facilities (objects disposed in toilets)
- Management is crucial!

Operation & Maintenance

- Reading gauges
- Recurring repairs or maintenance activities
- Stocking spare parts
- Care taker – day to day work
  - Inspection of vacuum system
  - Inspection of sanitation facilities

→ Needs of capacity development

→ Important: Responsibilities, leadership, delegation, execution

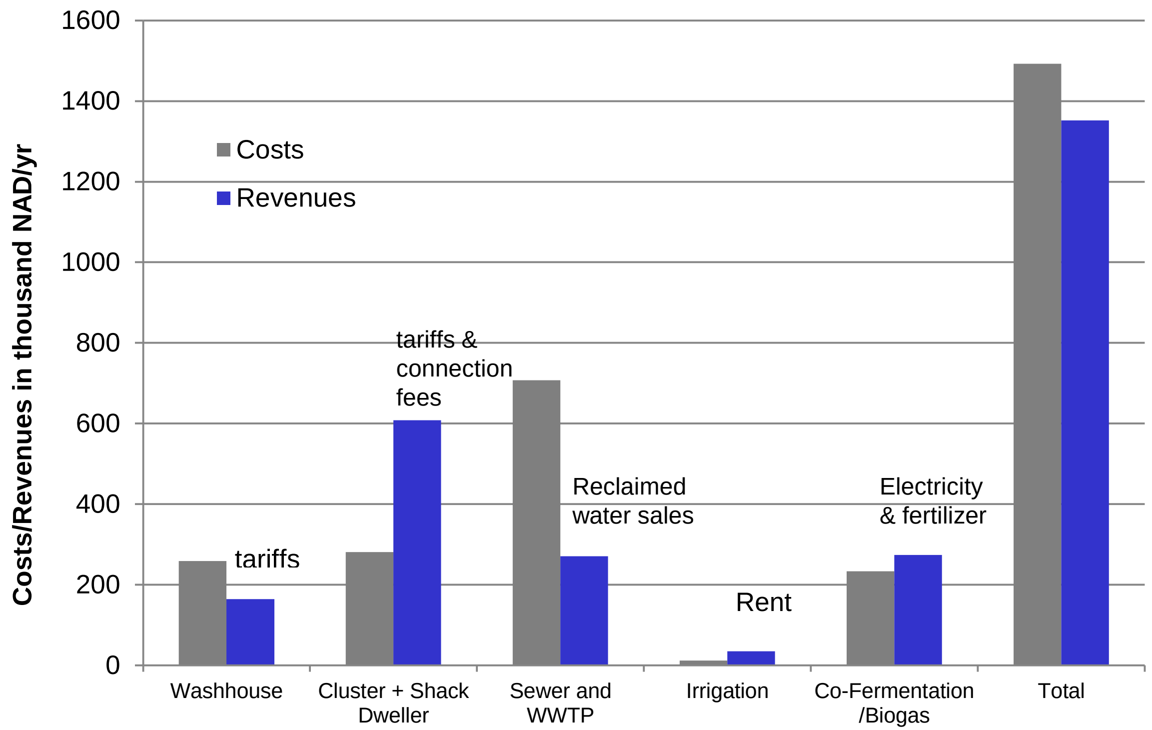
Results – Costs and Revenues

- Investment costs: ~18 million NAD (~1.3 million €) *(without including research equipment and costs)*
- O&M costs: ~1.5 million NAD/yr[(1)] (~107,000 €)
- Revenues : ~1.35 million NAD/yr[(1)] (~96,000 €)

→ *150,000 NAD/yr* (~10,000 €) to be subsidized

Capital Costs	
Component	**Costs [million NAD]**
Washhouse	1.1
30 Cluster Units	1.0
WW conveyance	5.4
WW treatment	9.9
Irrigation Site	1.0

(1) *When full capacity utilized*



Sanitation Facilites Overview

	Communal washhouse	Cluster units	Individual houses
How many facilities?	1	30	55
How many users?	250-350 users/day	240	220
How organised?	Cleaning personell, security staff	Committee of household members, self-organised cleaning, Shower use subsidises toilet use	Private cleaning
Tariff and payment	Payment per entrance (1.50 NAD per usage)	Swipe-card, topping up at OTC (30 N$/m³)	Bills send to household, paid at OTC (122.85 N$/month, 10.67 N$/m³)
Cost (of maintenance and water) & revenues (basic fee and water sale)	250,000 NAD costs 248,200 NAD revenues	75,000 NAD costs 109,000 NAD revenues	75,000 ND costs 148,000 ND revenues
Costs of building	1,080,000 NAD	1,020,000 NAD	-
Challenges	High O&M costs, calculation of entrance fee very important (ability to pay versus cost coverage)	balance between water use of showers and toilets	Incentivising private households to get connected

Successes and Challenges

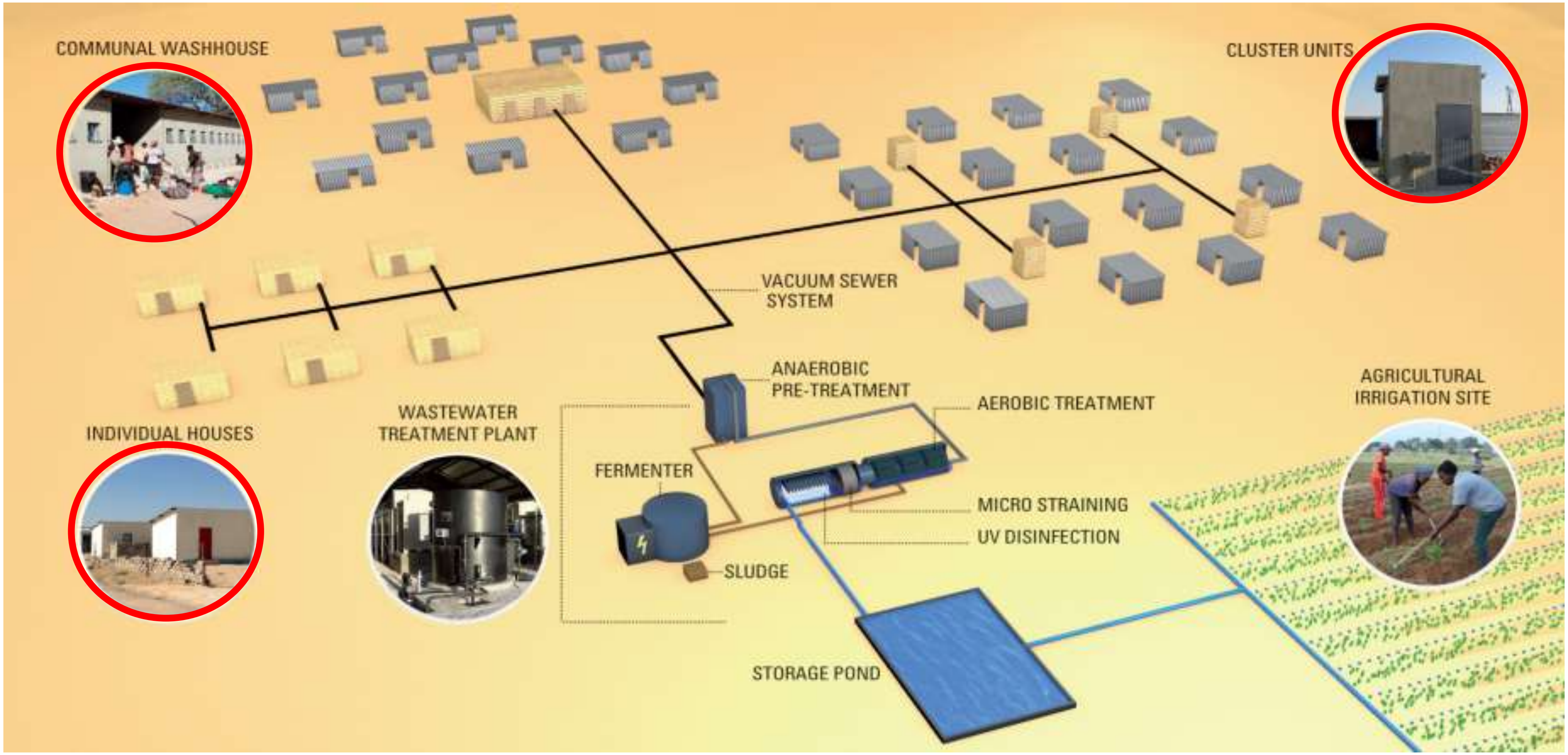
Successes

- Improved access to sanitation facilities for locals
- Decline in open defecation – improved health
- Relief of the overloaded stabilization ponds
- Reclaimed nutrient-rich water available for irrigation
- Creation of jobs (~12 permanent jobs, more temporary ones)
- 2 full-time OTC staff members trained and capable of operating the plant

Challenges

- Lower usage rate of the sanitation facilities than expected
- Use of reclaimed water and nutrients by farmers
- Ensure long-term O&M
  →technical personnel
  →adequate management
- Costs vs. tariffs

Overview over Sanitation Facilities



Demand-Responsive Approach (Community Level)

- Demand-responsive approach
  - Qualitative social research
    → Collection of empirical data
  - Participatory planning methods
    → Integration of stakeholders
- Aims
  - Integration of social realities of community members
  - Implications for design and implementation of proposed techniques

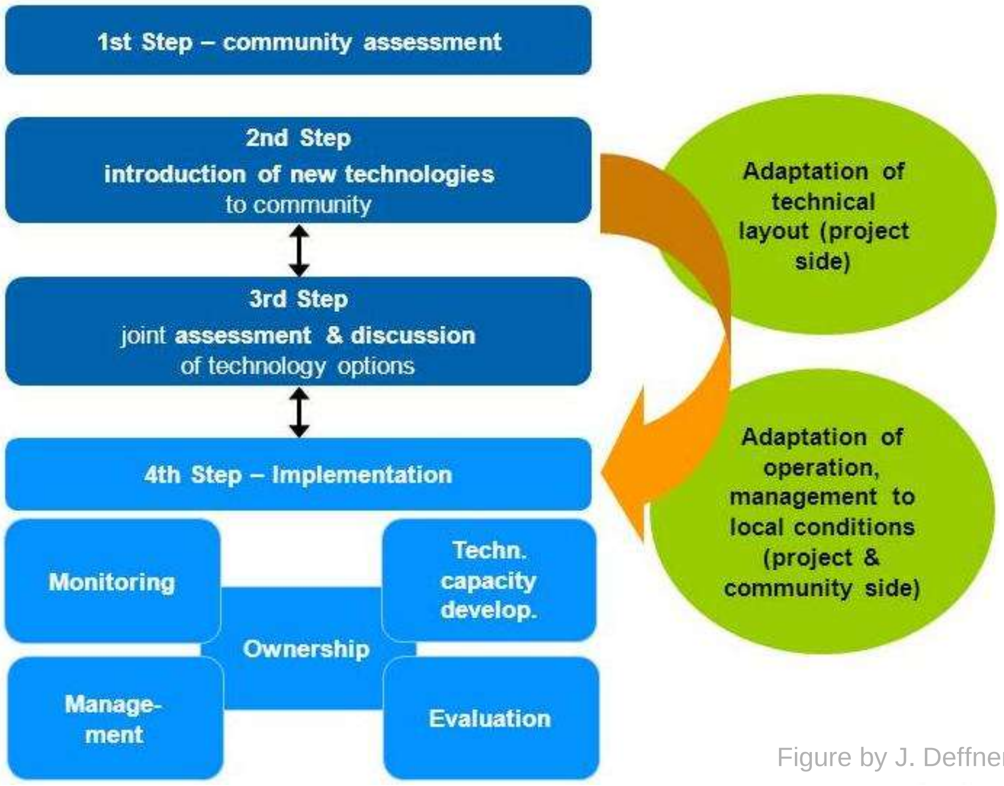


Figure by J. Deffner

Communal Washhouse

- About 150 users per day
- Payment per entrance (1.50 NAD per usage)
- O&M comprises cleaning personell, security staff
- Calculation of entrance fee very important
- Challenge: balancing the users‘ ability to pay vs. cost coverage

Cluster Units

- 30 Clusters used by 240 people (1 cluster unit shared by 3-4 households)
- Swipe-card (30 N$/m³)
- Committee of households who share Cluster
- Self-organised cleaning
- Shower use subsidises toilet use
- Challenge: balance between water use of showers and toilets

Shack Dwellers

CUVEwaters integrated water resources management

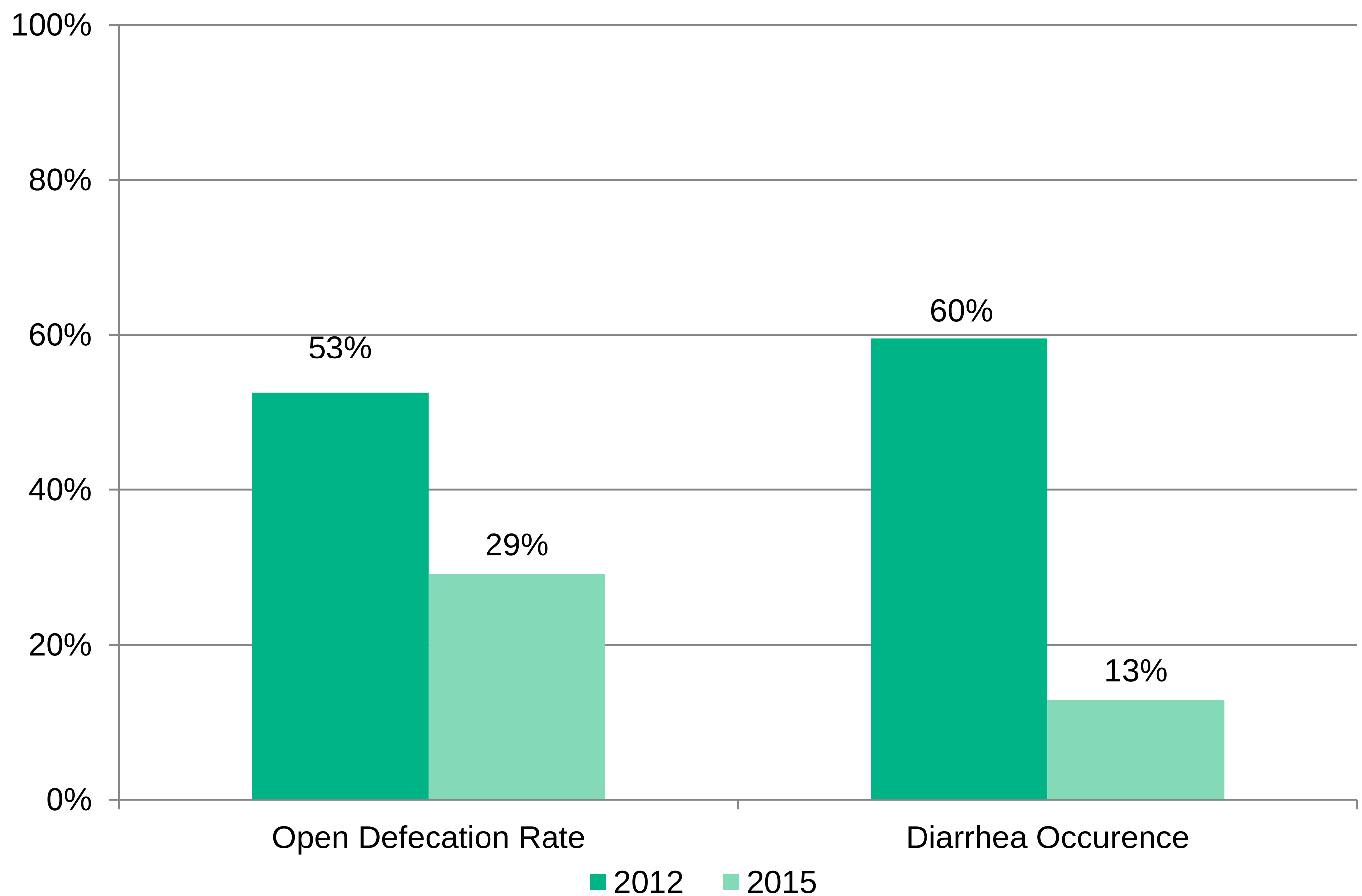
- 55 households are connected (220 users)
- Bills send to households, paid to OTC (122.85 N$/month, 10.67 N$/m³)
- Generates revenues for muncipality
- Good cooperation between municipality and shack dwellers federation
- Challenge: Incentivising private households to get connected

Community Health Clubs (CHC)

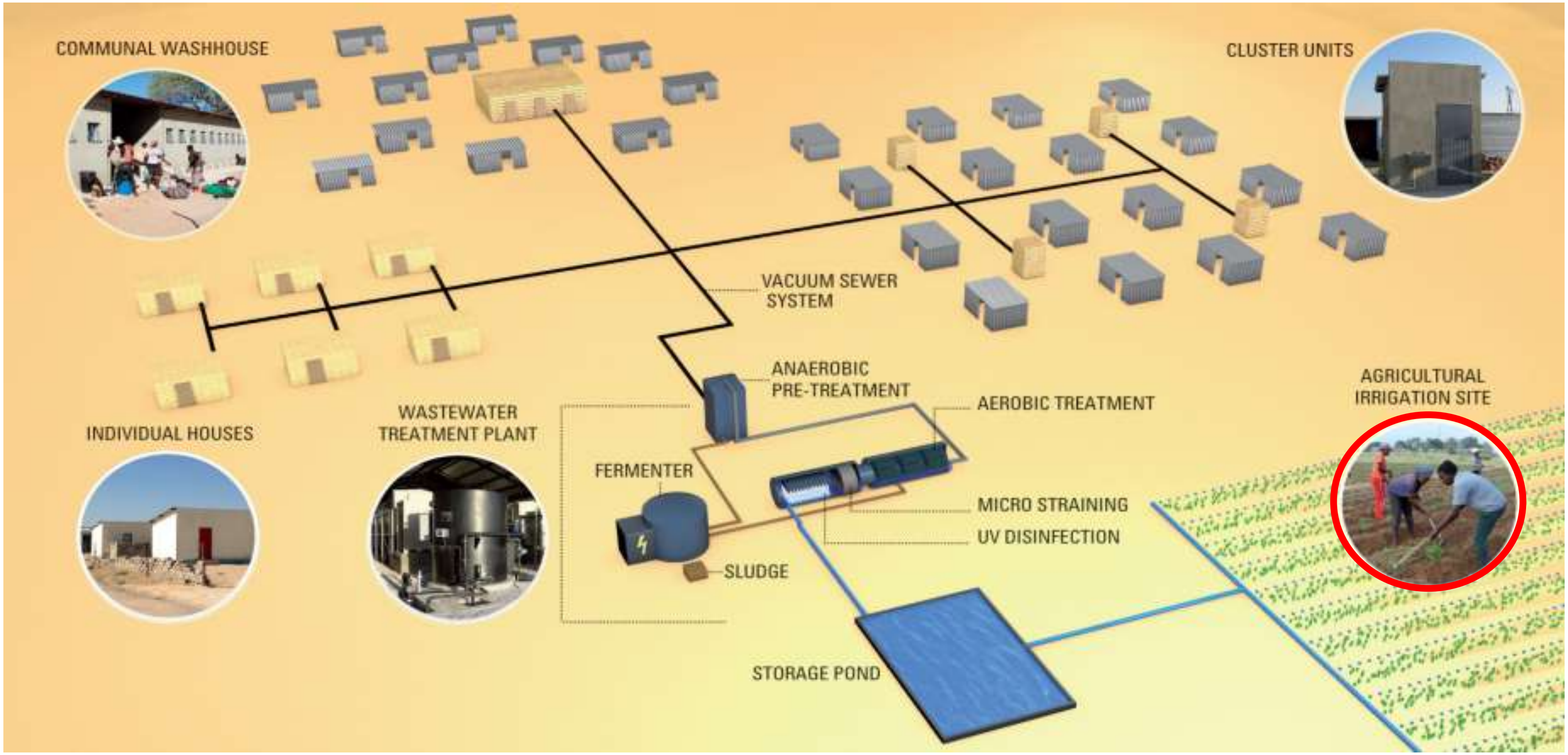
- In a voluntary community based training process inhabitants learnt preventing common diseases in their area through safe hygiene practices.
- Objectives:
  - Achieving a long lasting change of hygiene behavior
  - Establishing a routine of using toilets, showers and washing basins
  - Communicating benefits of sanitation facilities and adequate usage of new facilities

Improved Hygiene and Health

- Households performing open defecation and reporting diarrhea problems in the family within the past 2 weeks



Agricultural Irrigation



Technical Specifications

- Water from treatment plant is hygienically save for reuse in agriculture
- Nutrients (N, P, K) are left in the water for fertigation
- Pond of 3,700 m³ used for irrigation water storage (buffers fluctuations)
- Drip irrigation used to minimize water losses by evaporation and infiltration
- High tanks (70 m³) generate pressure of 0.6 to 0.9 bar

Crop Production and Yields

- Net field size: approx. 3 ha
- Recommended irrigation water volume by FAO: 12,690 m^3/ha/a (34.8 m^3/ha/d)
- Crops produced: tomato, green pepper, maize, water melon, pumpkin
- Harvest of 32.4 to 42 t/ha/a of fruits and vegetables

Financial and Institutional Aspects

- Capital expenditures for replication: approx. 1,000,000 NAD
- Revenues and selected costs:

	N$ per hectare and year	**N$ per 3 hectare and year**
Revenues	420,000	1,260,000
Irrigation water costs (treated water or mixture of treated water and tap water)	108,000 to 132,000	324,000 to 396,000
Leasehold	11,600	34,800
Profit for farmer (rounded, without salaries)	277,000 to 300,000	830,000 to 901,000

- Institutional setting:
  - Farmer pays leasehold to OTC (2,900 NAD per month)
  - OTC sells reuse water to local farmer (8,25 NAD/m³)

Conclusions

- Steady supply of nutrient rich water means a high reliability for farmer
- Processed products generate a higher income (e.g. tomato jam and powder)
- Local food production increases food security and substitutes imports
- Several full-time and part-time jobs created
- Achieved revenues indirectly subsidize water and sanitation tariffs
  → affordability for local users

Thank you for your attention!

p.cornel@iwar.tu-darmstadt.de
outapitc@iway.na
zimmermann@isoe.de
www.cuvewaters.net

CUVE waters integrated water resources management

Making local water sources available for crop production

Research results rain- and floodwater harvesting for small-scale horticulture in central-northern Namibia

PD Dr. Thomas Kluge

ISOE – Institute for Social-Ecological Research

First Kenyan-German Water and Wastewater Week

Nairobi, October 11th, 2016

SPONSORED BY THE

Federal Ministry of Education and Research

Institute for Social-Ecological Research

IWAR TECHNISCHE UNIVERSITÄT DARMSTADT

In cooperation with

giz BGR

FONA Sustainable Water Management BMBF

Industry partners

BILFINGER

proaqua

terra water

Background Situation

- Highly variable climate poses high risks to farming
- Diet and health status poor
- Lack of opportunities for income generation

- **Solution: Horticulture with irrigation**
- **What is needed? : Water storage**

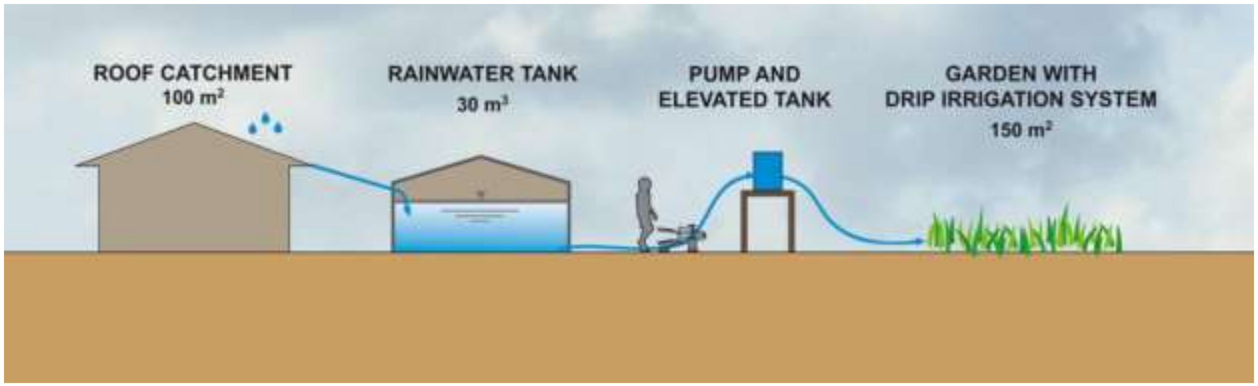
Local „under-utilised“ water resources

- **Rainwater**

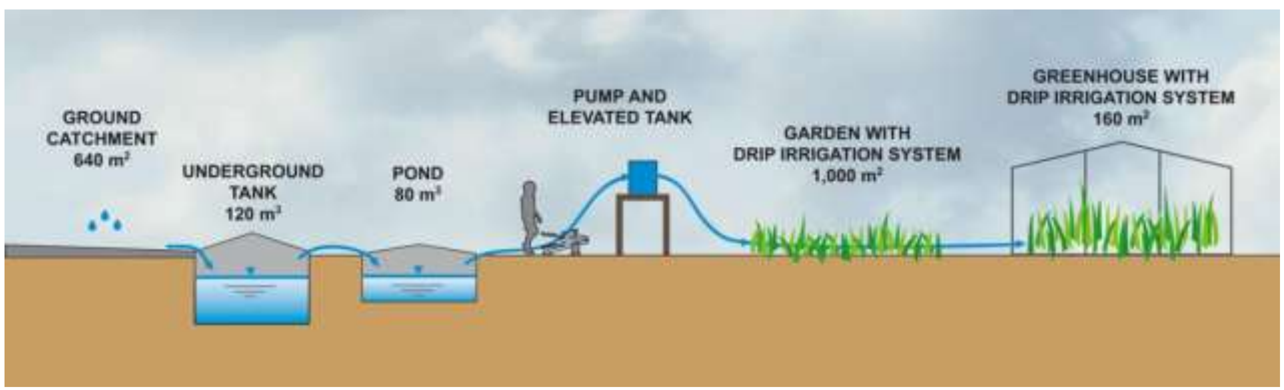
- **Oshana Floodwater**

Cheap and basic technologies needed for implemetation in rural areas

Rainwater Harvesting



Household approach: Ferrocement Tank, Brick Tank, Polyethylene Tank



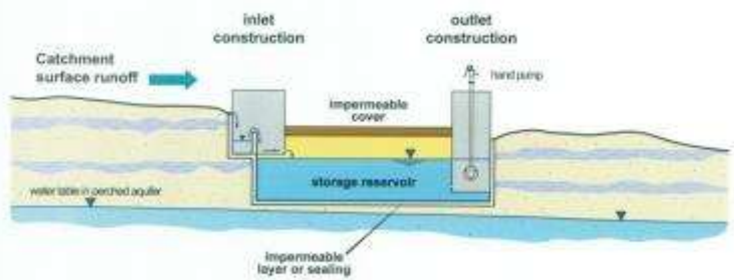
Communal approach: Underground Tank, Ground Catchment, Pond
Greenhouse, communal garden **„Green Village“**

Rainwater Harvesting
Construction sites in Epyeshona 2009-2010

Rainwater Harvesting

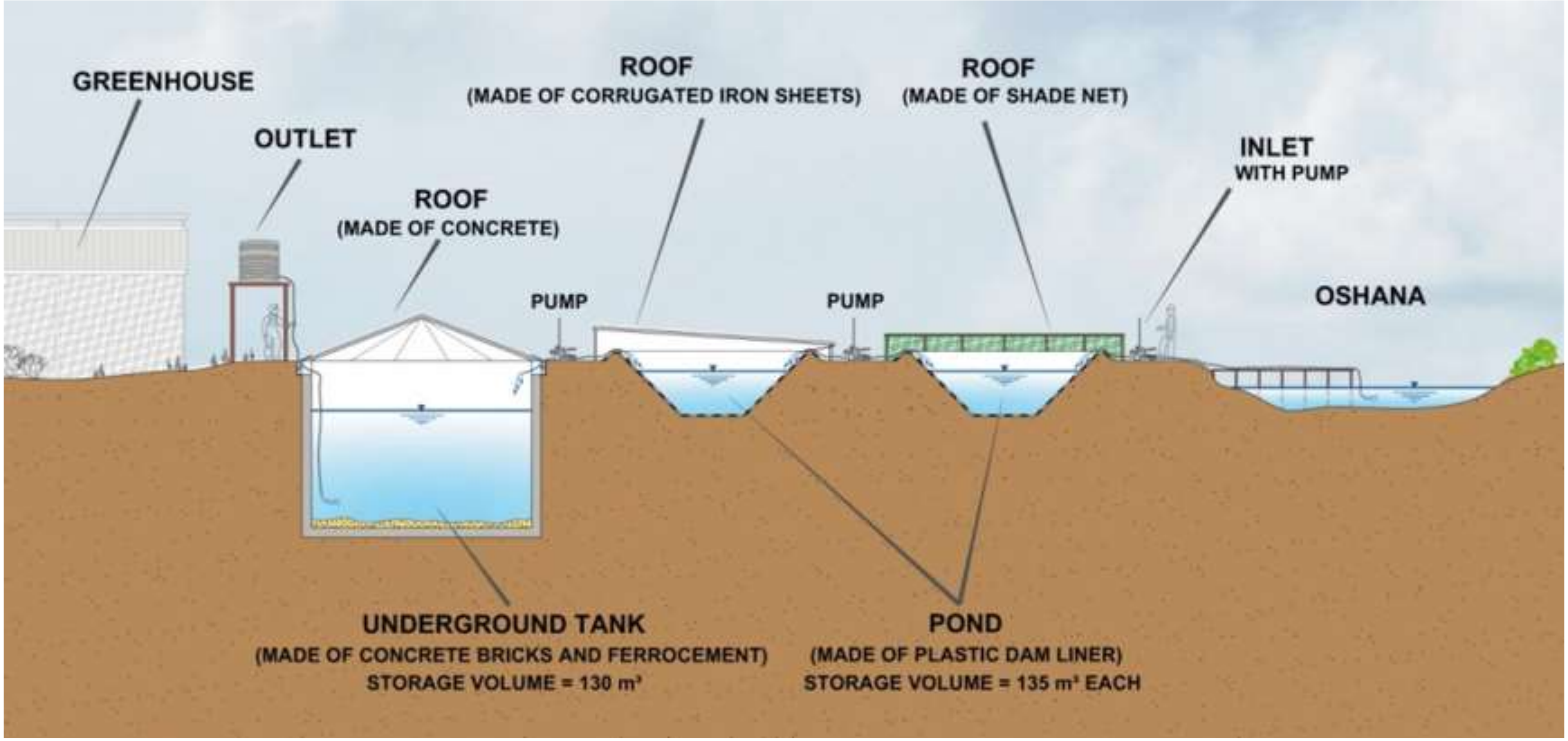
Underground Water Storage -> Subsurface Water Storage ->

Floodwater Harvesting



- Expert Workshops in Windhoek
- Stakeholder Workshops in Iipopo
- Technical research
- Field research

Floodwater Harvesting



Floodwater Harvesting
Construction site 2011

- 40 people from local community
- 6 weeks
- Underground tank, 2 ponds, greenhouse, garden, fence, storage room
- Infrastrucural additions in 2012 and 2014

Floodwater Harvesting „Green Village“

Technical recomendations
Rain- and Floodwater Harvesting

- **Household level: Ferrocement Tank 30 m³**

Roll-out: N$ 9,000/tank

Yearly maintenance
Tank: N$ 75
Household garden: N$ 375

- **Communal level: Pond with shade net (135 m³)**

Roll-out: N$: 20,800/pond

Yearly maintenance
Pond: N$ 1,125
Community garden: N$ 1,875

  - Low material costs
  - Good availability of material
  - Quick construction (5-6 days)
  - Easy to construct, no machinery needed
  - Low maintenance costs

Local Capacity Development

- **Construction Training**
  - Tanks
  - Ponds
  - Greenhouses
  - Drip irrigation
  - Site management

- **Horticulture Training**
  - Soil preparation
  - Plant care
  - Harvest and selling
  - Bookkeeping and montoring

Long term advice and guidance neccessary!

Benefits

- **Mitigates the risks of climate variability and change**
- **Diet and health situation is improved**
- **Jobs are created in construction and farming**
- **Income generation by selling of vegetables**
  - single households up 12,000 N$ per year

Recomendations

Starting point

- Demand for water / interest within the community

Social and organisational

- Long term capacity development
- Different age groups, women empowerment, short distances to homesteads and customers

Technical

- Assistance in accounting and bookkeeping
- long term guidance in farming (involvement of extension services)
- **Enabling environment (e.g. availabilty of spare parts, extension services, policies)**

Creating an enabling environment

- **Rain- and Floodwater Harvesting is associated with low running but high investment costs**
- **Infrastructure investment costs unaffordable for rural residents**
- **Running costs (e.g. maintennace, tools, seeds, fertilizer) can be paid by the owners from income generated,**
- **BUT investment costs have to be financed by government or donors**

Policy

- Rainwater Harvesting projects have to be linked with new Namibian policies; eg. for small scale horticulture and conservation agriculture

Possible financing

- Ministry for Agriculture, Water and Forestry **(MAWF)**, Ministry of Urban and Rural Development **(MURD),** Ministry of Poverty Eradication and Social Welfare
- **EIF, GIZ, EU**, others

UNAM Campus Ongwediva
Rainwater Harvesting Field Laboratory

- Constructed during „Train the Trainer Rainwater Harvesting“ course in 2014
- Cooperation by CuveWaters, TU Kaiserslautern, FU Berlin; financed by GIZ
- Can be used by UNAM for research and education

„Train the Trainer“ Horticulture with harvested rainwater

Handing Over Iipopo and Epyeshona

Agricultural Extension Services for Rain- and Floodwater Harvesting farmers

CUVEwaters integrated water resources management

Ministry for Agriculture, Water and Forestry (MAWF), Director of the Directorate for Agricultural Production, Engineering and Extension Services (DAPEES)
Ms. Sophie Kasheeta
Windhoek

Deputy Director of the Directorate for Agricultural Production, Engineering and Extension Services (DAPEES) for central-northern Namibia, Ongwediva
Mr. Emalwa
Ongwediva

Supervisor for Agricultural Extension Officers
Ms. Loide Endjara
Ongwediva

Agricultural Development Center Uukwangula, Agricultural Extension Officer for southern Okatana Constituency
Ms. Prucheria
Uukwangula

Agricultural Development Center Uukwangula, Agricultural Extension Officer for northern Okatana Constituency
Ms. Ndilimeke
Uukwangula

Green Village Iipopo


Green Village Epyeshona


Household Tanks and Gardens Epyeshona


Rainwater Harvesting Field Lab Ongwediva


Outlook

- Between 2013 and 2015 Namibian institutions and NGOs already constructed Rainwater Harvesting „Green Villages“ in Onamishu, and Oshikoto
- Further inquiries for financing are pending for the villages Onaanda, Xx and in Rundu
- **The Directorate of Agricultural Production, Engineering and Extension Services of the Ministry for Agriculture, Water and Forestry is able and willing to support and give advice to existing as well as coming rain- and floodwater harvesting ventures**

■ **Thank you very much for your attention!**

Tackling water poverty

Experiences with O&M from small scale groundwater desalination and rain- and floodwater harvesting technologies

PD Dr. Thomas Kluge

ISOE – Institute for Social-Ecological Research, Frankfurt/Main

First Kenyan-German Water and Wastewater Week

Nairobi, October 11th, 2016

SPONSORED BY THE

Federal Ministry of Education and Research

In cooperation with

Industry partners

Outline

- Introduction
- Small scale groundwater desalination
- Rain- and floodwater harvesting
- Framing activities
- Creating an enabling environment
- Success factors for implementation
- Conclusions

Project Approach

Multi-Resource-Mix

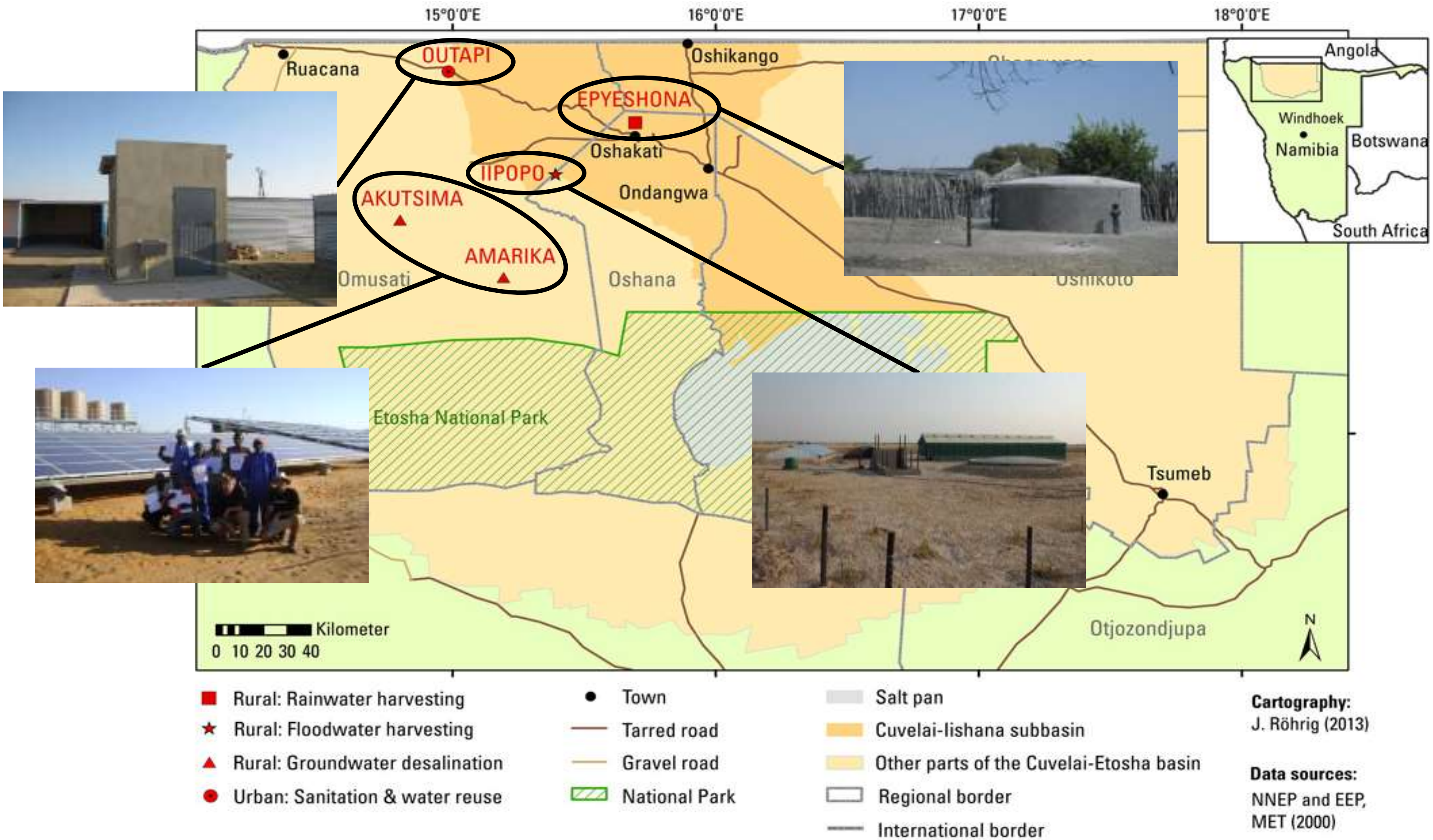
Rain- and Floodwater Harvesting (RFWH)		Solar-linked Groundwater Desalination	Wastewater Treatment and Water Re-use
Gardening (individual)	Gardening (communal)	Drinking water (health)	Hygiene, Gardening (communal)

Support and Framing

Knowledge Management	Empirical Studies	Participation	Governance, Institutions	Capacity Development

Improving the living conditions of the people through innovative water supply and sanitation technologies which are adapted to the regional economic, ecological and social conditions

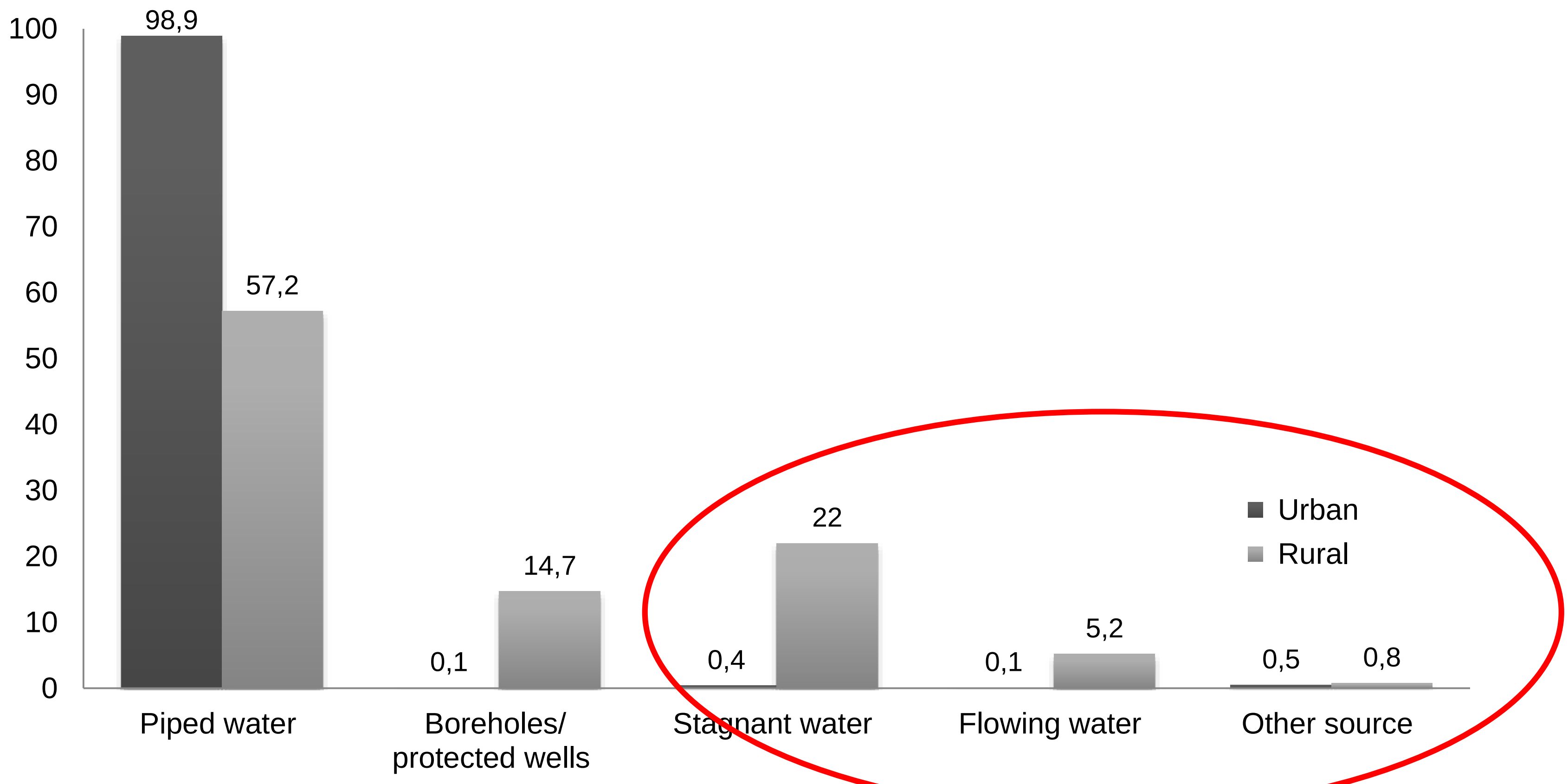
Project Region



Small-Scale Groundwater Desalination

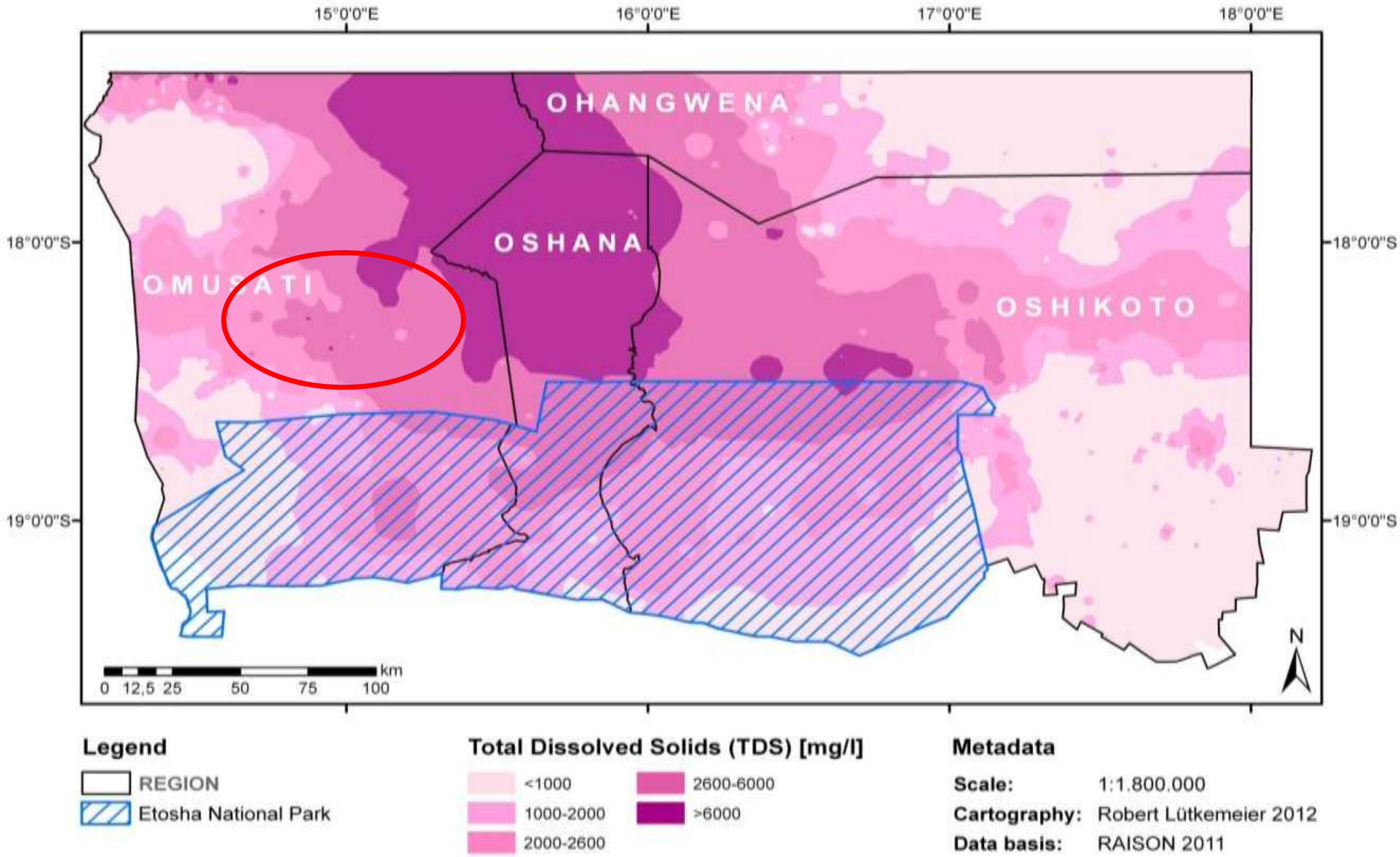
Small scale groundwater desalination Background (I)

- Main sources of drinking water in Namibia



Source: Namibia Statistics Agency, Namibia household Income and Expenditure Survey 2009/2010

Small scale groundwater desalination
Background (II)



Small scale groundwater desalination
Background (III)

Small scale groundwater desalination Technologies

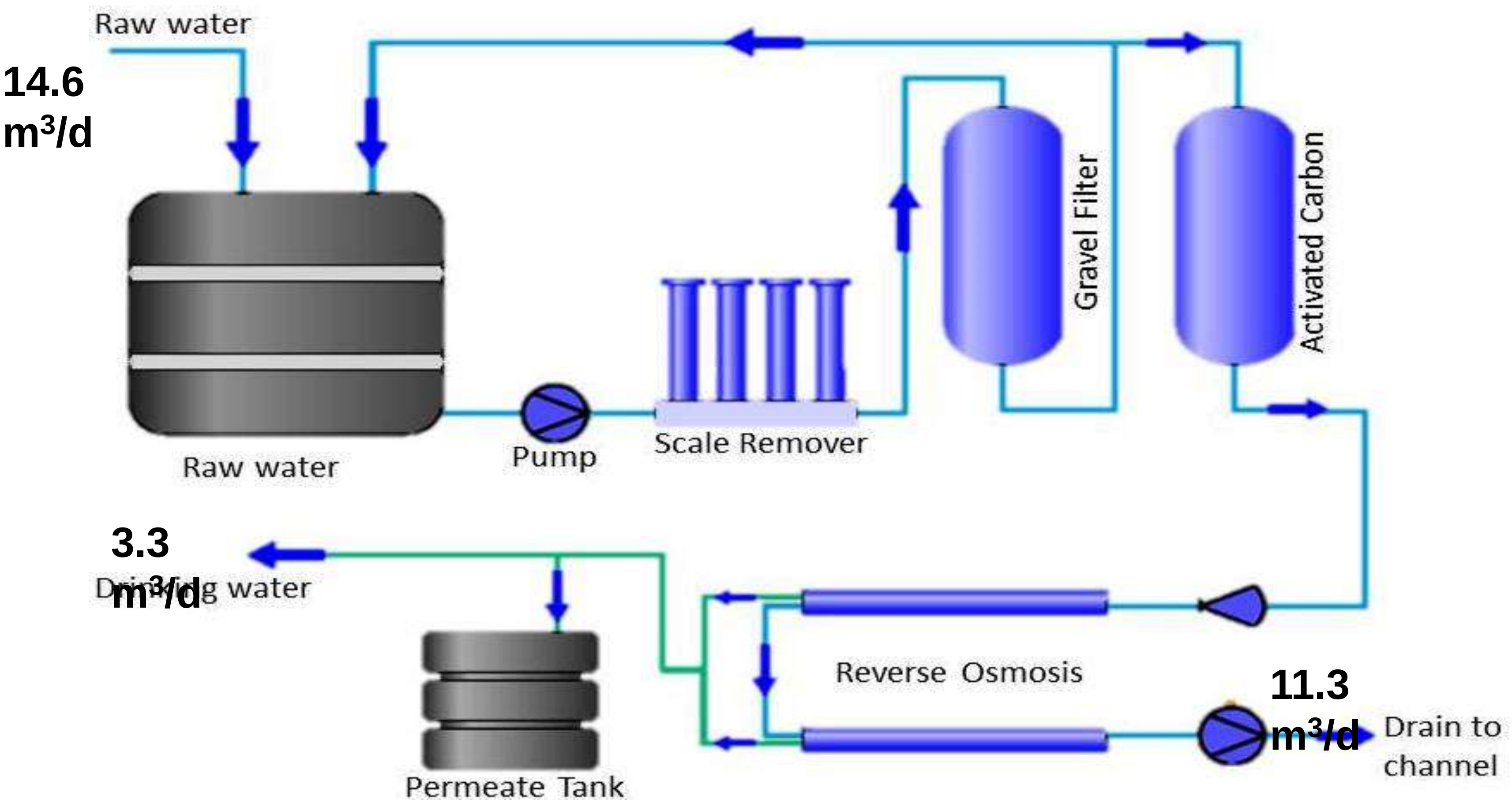
CUVE waters integrated water resources management

- Reverse Osmosis (RO)
- Humidification–Dehumidification (HDH, MEH)
- Multi-Stage Desalination (MSD)

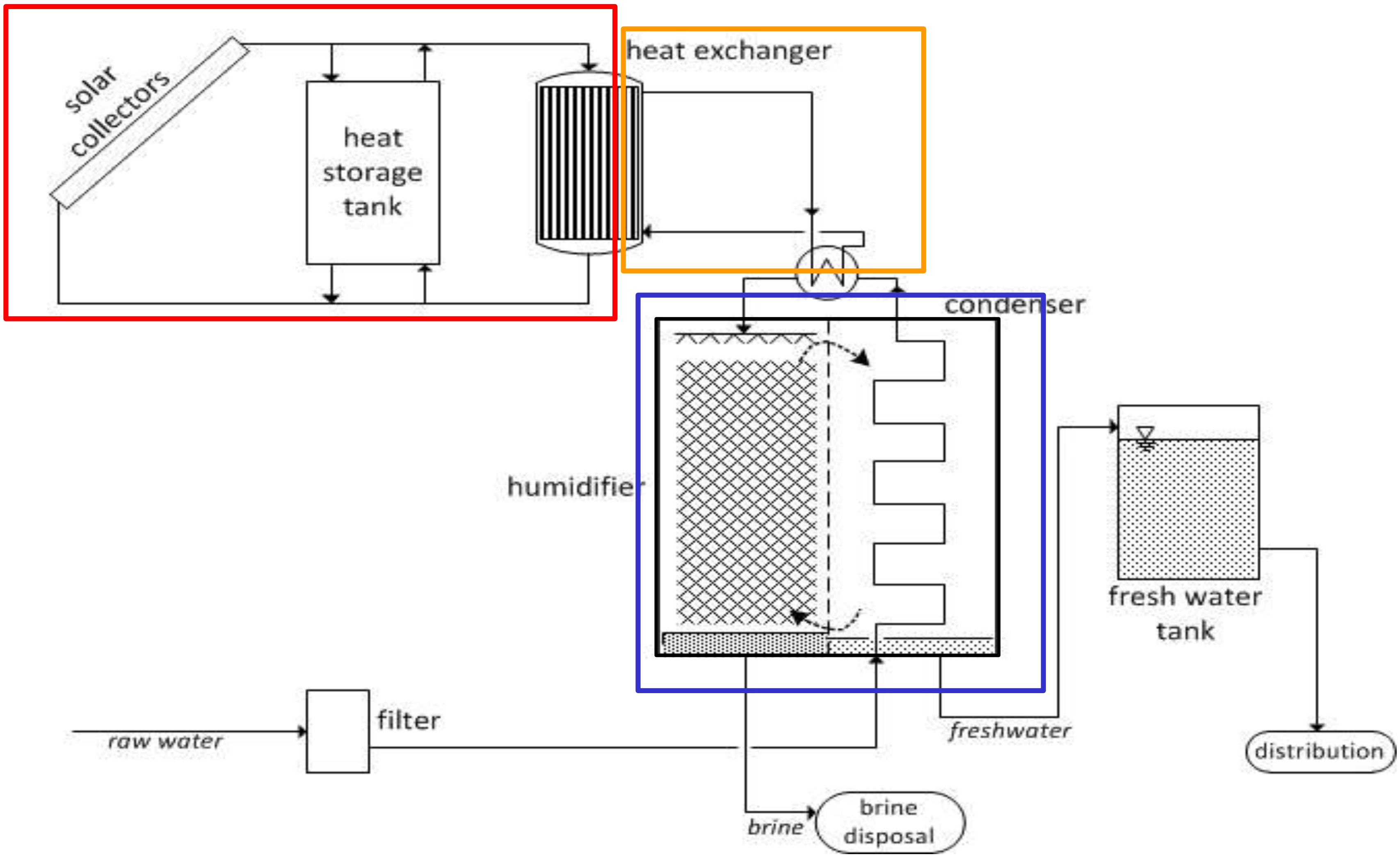
Small scale groundwater desalination
By-infrastructure: key data

	Amarika	Akutsima
Raw water well capacity [m^3/d]	120	216
Conductivity of raw water [µS/cm]	35,000	7,500
Depth of raw water well [m]	50	50
Raw water demand of plants [m^3/d]	14.1	17.9
Brine production from plants [m^3/d]	10.8	15.9
Conductivity of brine [µS/cm]	43,400	8,500
Area of evaporation pond [m^2]	3,364	2,704
Installed PVs [m^2]	142	102
Installed PVs [kWp]	19.8	14.8

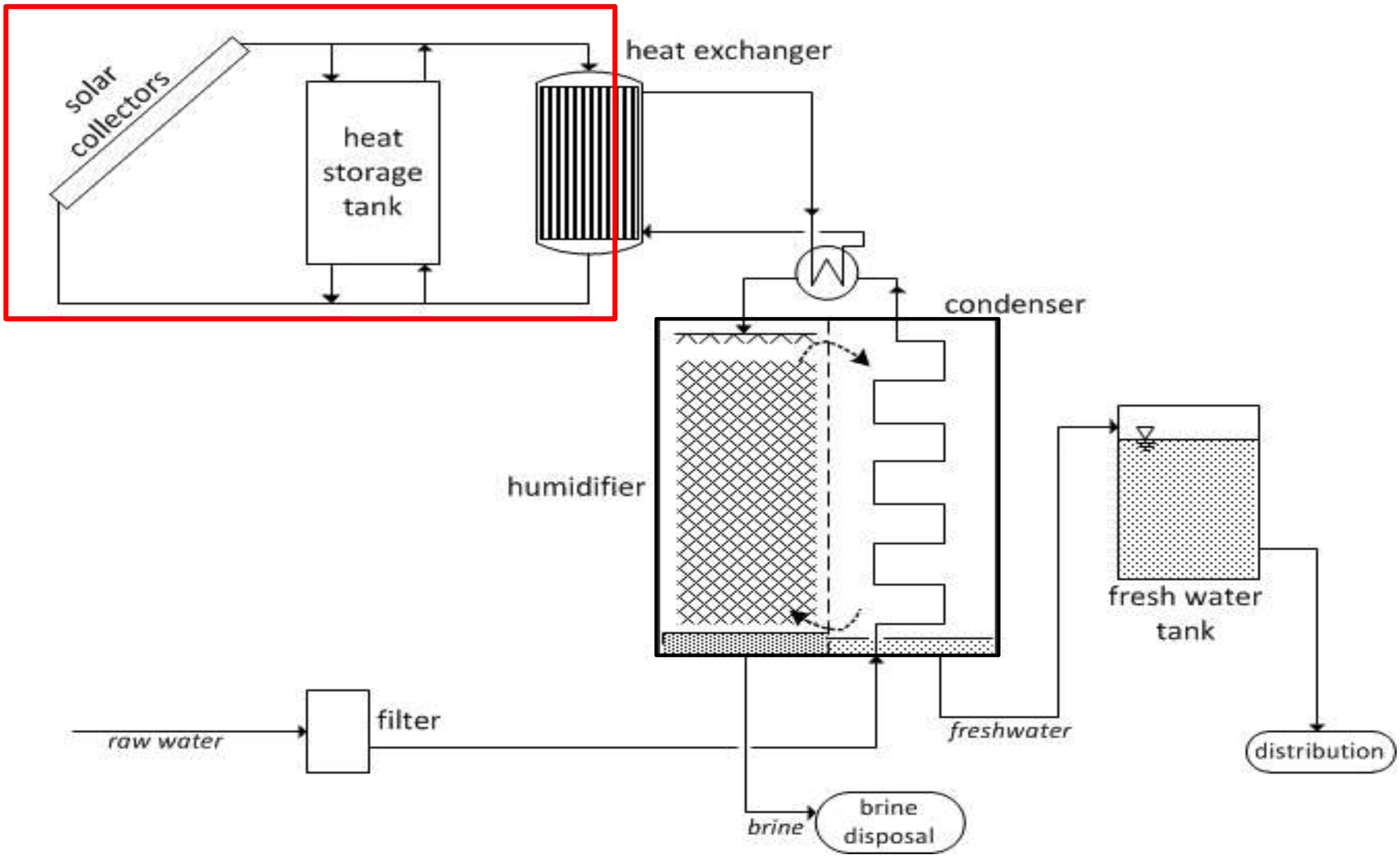
Small scale groundwater desalination Technologies – RO



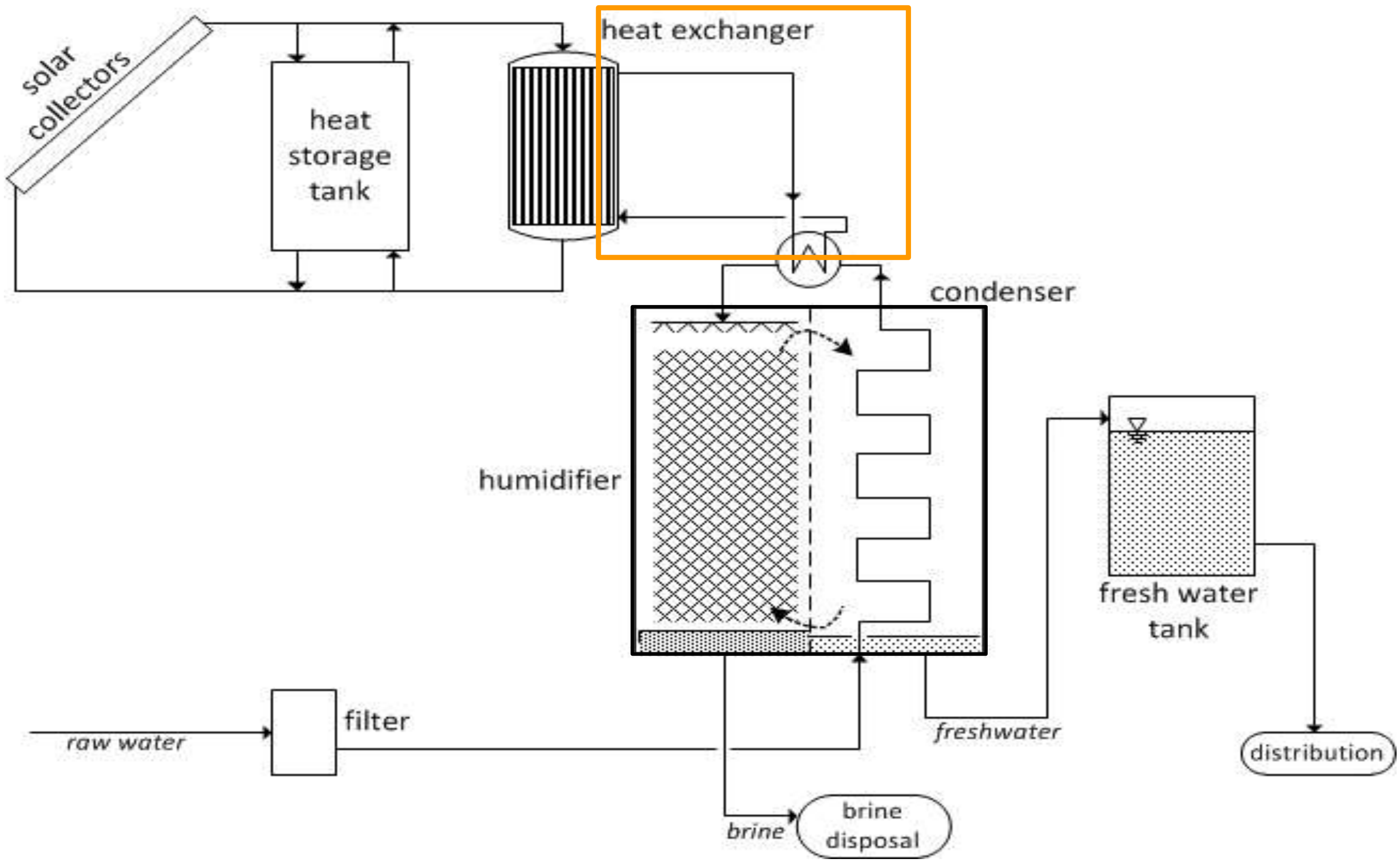
Small scale groundwater desalination Technologies – HDH



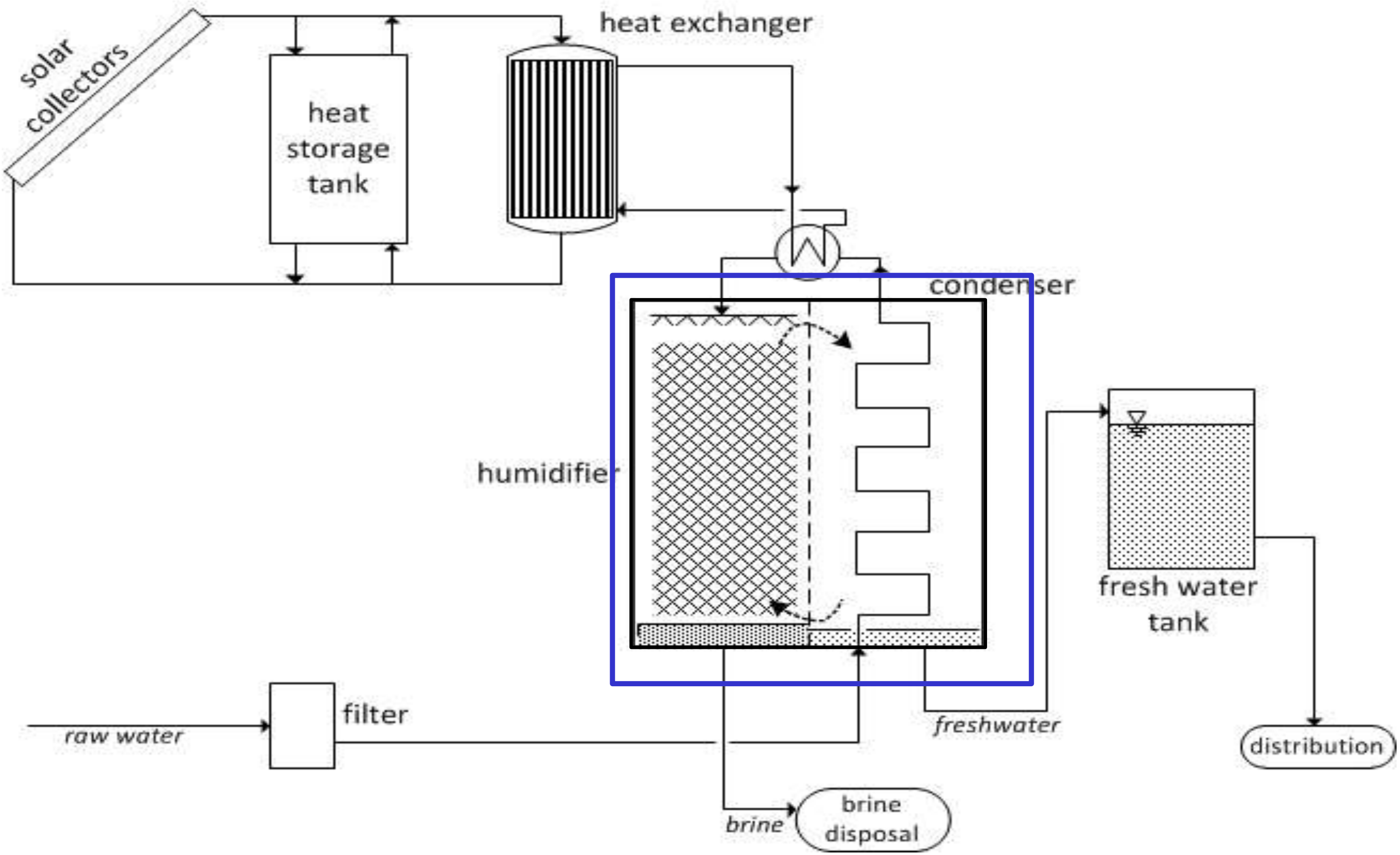
Small scale groundwater desalination Technologies – HDH



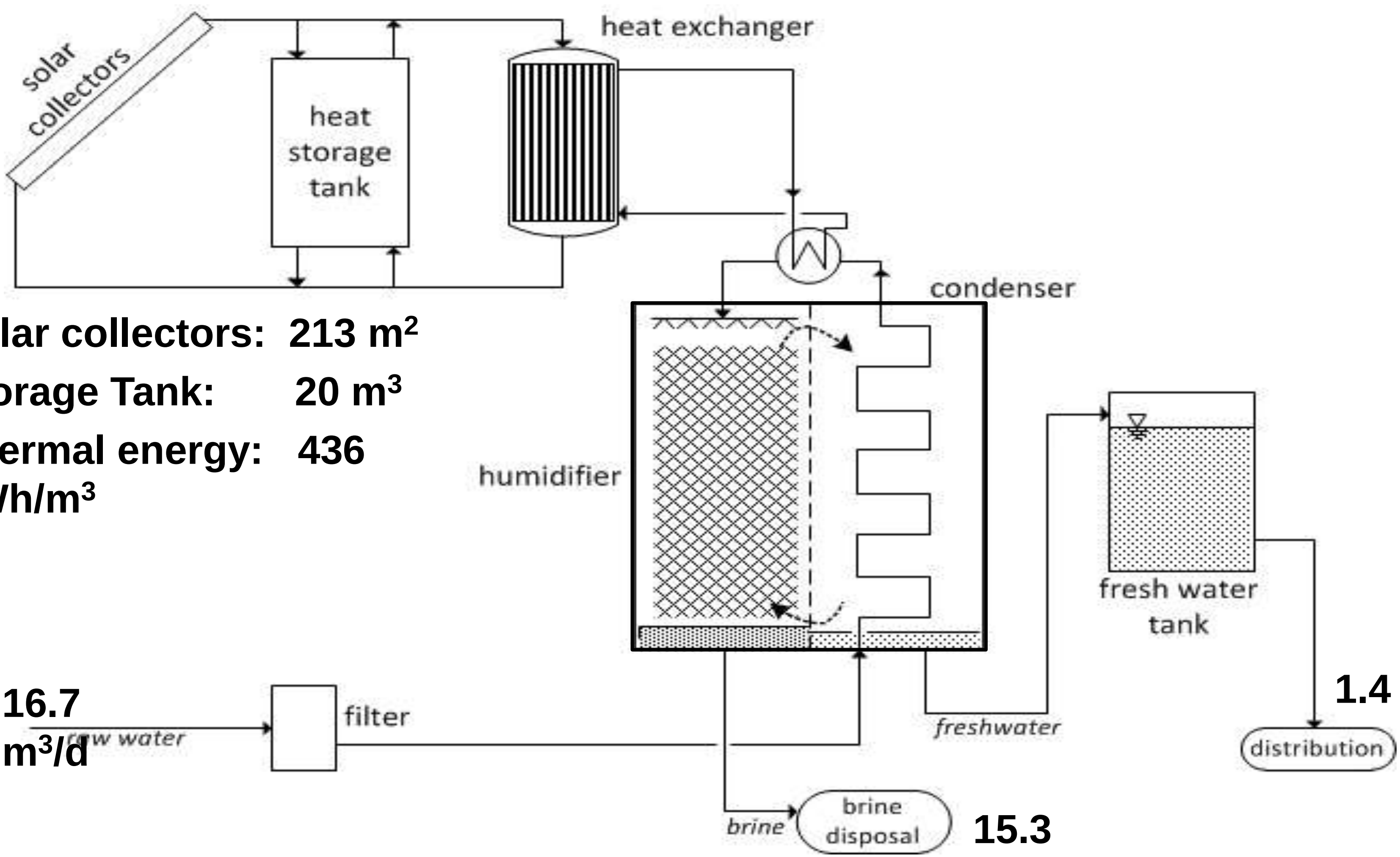
Small scale groundwater desalination Technologies – HDH



Small scale groundwater desalination Technologies – HDH



Small scale groundwater desalination Technologies – HDH



Solar collectors: 213 m²

Storage Tank: 20 m³

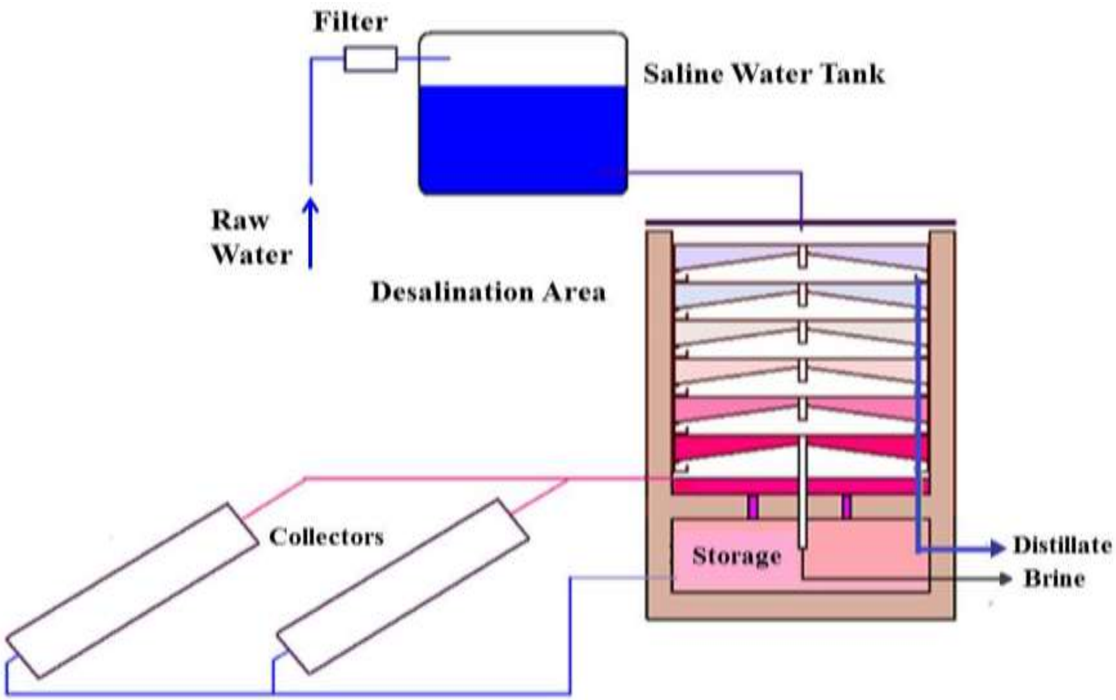
Thermal energy: 436 kWh/m³

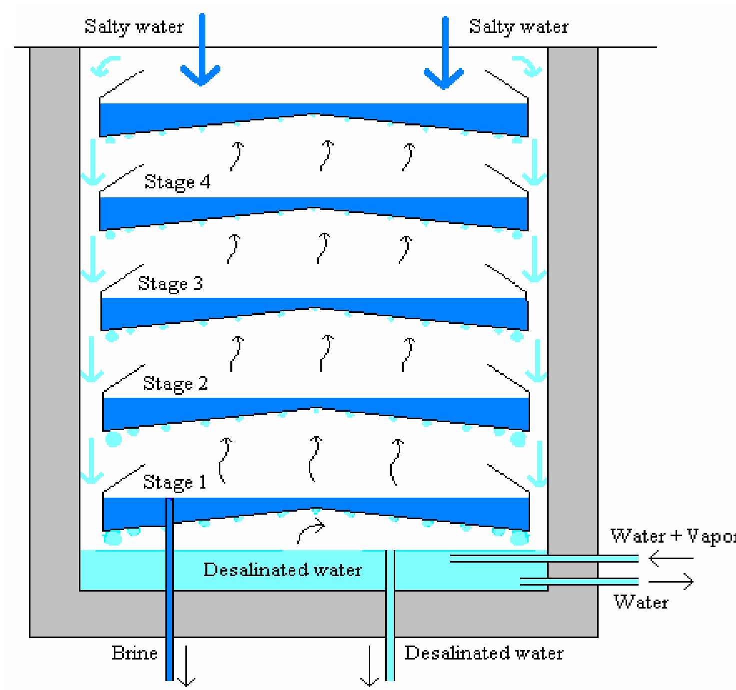
16.7 m³/d

1.4 m³/d

15.3 m³/d

Small scale groundwater desalination Technologies – MSD

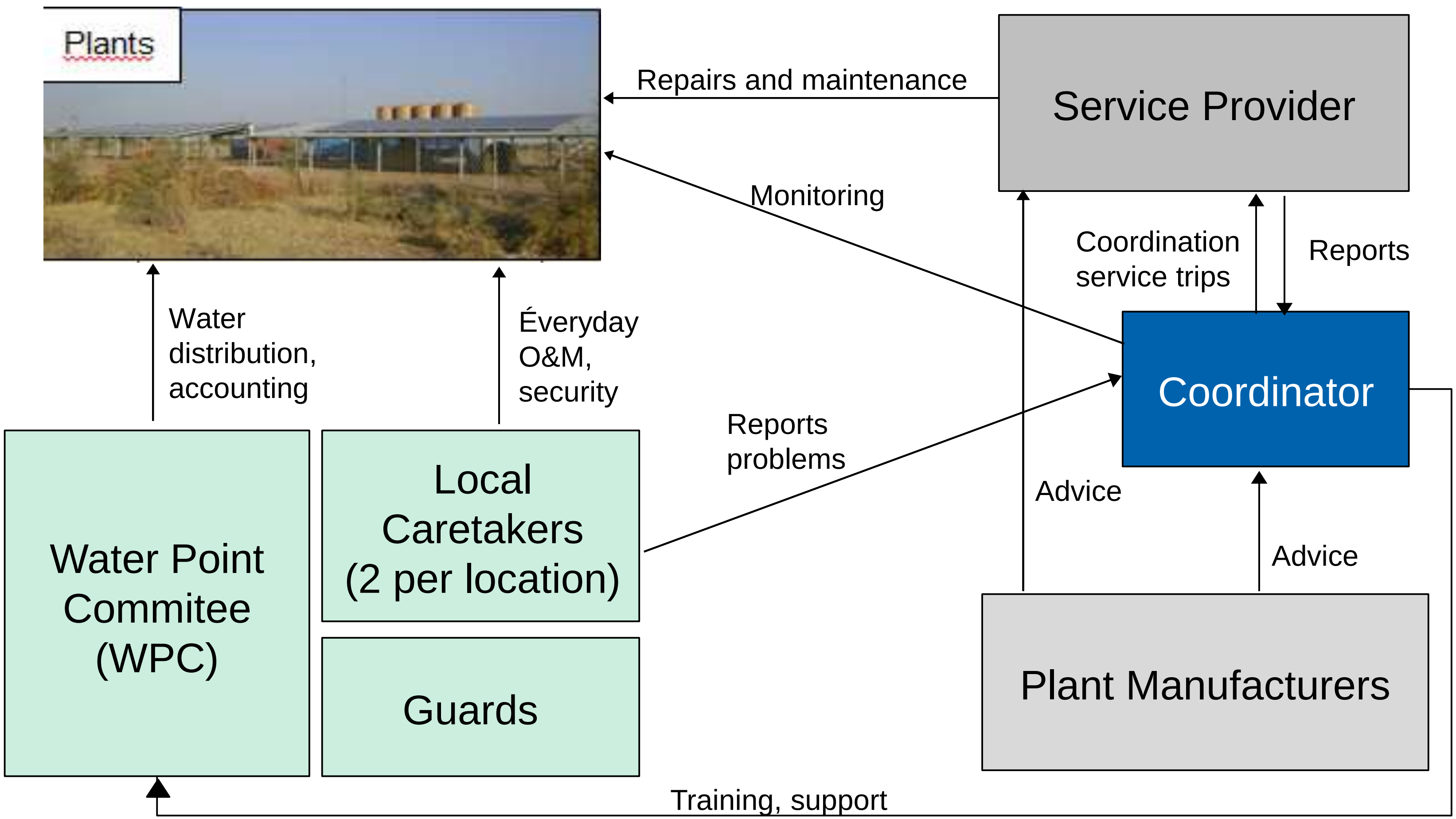




Raw Water Demand: 85 L/d
Freshwater Production: 42 L/d
Thermal Energy: 404 kWh/m^3

Average values for 1 module!

Small scale groundwater desalination
Operational concept



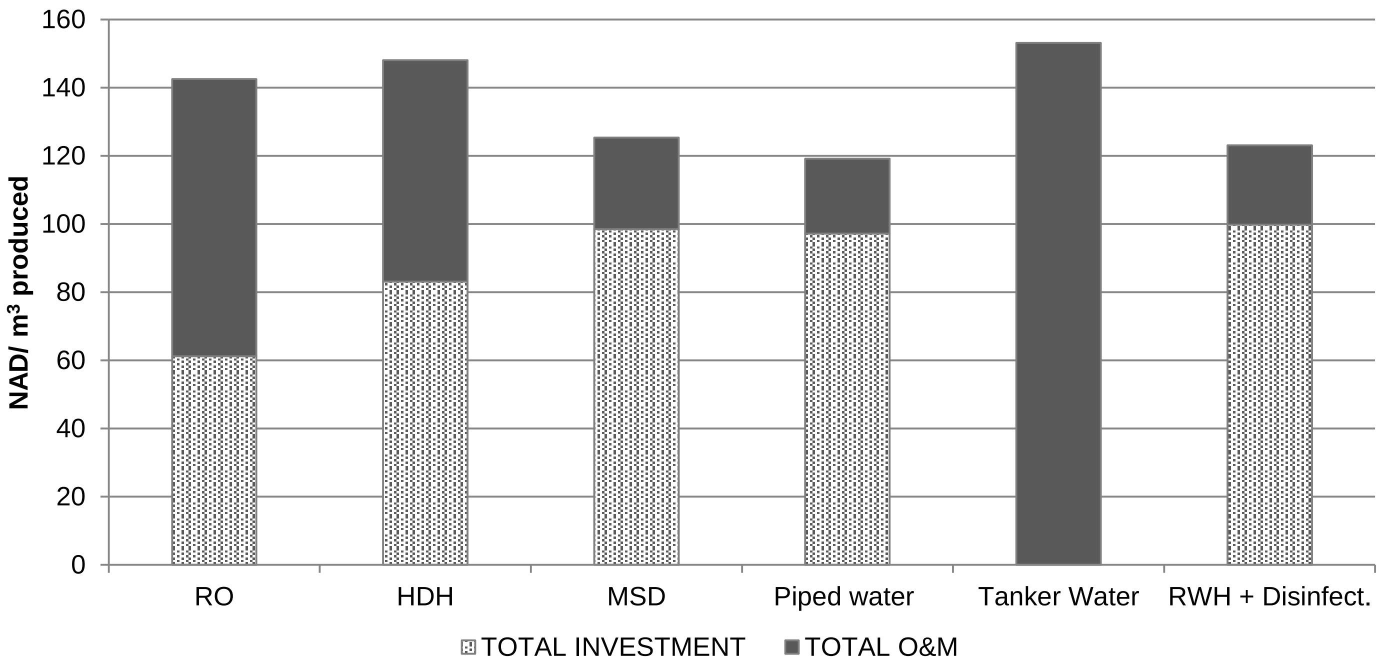
Small scale groundwater desalination
Monitoring Results

	RO	HDH	MSD
Salinity of raw water [µS/cm]	35,000	7,500	7,500
Salinity of product water [µS/cm]	980	6	5-10
Daily freshwater production [m^3/d] (max. reached in brackets)	3.3 (4.7)	1.4 (2.1)	0.25 (0.6)
Daily raw water demand [m^3/d]	14.1	16.7	0.5
Daily brine production [m^3/d]	10.8	15.3	0.25
Specific electric energy demand [kWh/m^3]	7.9	NA	0
Specific thermal energy demand [kWh/m^3]	0	436	404
Chemical water quality class	B	A	A
Microbiological water quality class	B	B	B
Maintenance needs	med/high	med/high	low
Appropriate implementation level	Community	Community	Household

Small scale groundwater desalination
Costs

Total Costs per m³ water produced in NAD (market case)

	RO	HDH	MSD
Capacity [m³/d]	5	6	1.6
INVESTMENT	61	83	98
O&M	81	65	27
TOTAL	143	148	125



Small scale groundwater desalination
Successes and challenges

Successes

- Practical on the ground experience with technologies → appropriate.
- Safe water for local population
- Enhancement of skills and

Challenges

- Some level of know-how should be established beforehand → skills
- Novelty of technology → success too dependent on individuals
- Integration in established institutions and procedures cumbersome
- Availability of spare parts locally

Small scale groundwater desalination Conclusions – Recommendations

- Small scale solar driven desalination technically is feasible
- Costs lay within the same range as alternatives in the region
- Regular O&M are crucial → budget and skills !!!
- Clear supply chain for spare parts
- Early integration in existing structures and processes
- Development of ownership feeling within the community and the responsible institutions
- Professional political/institutional support

Contacts

- **Information about the project**
  - **ISOE – Institute for Social-Ecological Research**
    Dr. Jenny Bischofsberger
    Tel. +49-69-7076919-20
    E-Mail: bischofberger@isoe.de

- **Technical project information Desal and RFWH**
  - **Prof. Dipl.-Ing. Dr. nat. techn. Wilhelm Urban (Technische Universitaet Darmstadt)**
    Tel. +49-6151-16-20805
    E-mail: w.urban@iwar.tu-darmstadt.de

  - **www. cuvewaters.net**